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EVALUATION OF A PHOTOGRAPH-BASED CITIZEN SCIENCE PROGRAM AS A TICK SURVEILLANCE AND PREVENTION EDUCATION TOOL

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EVALUATION OF A PHOTOGRAPH-BASED CITIZEN SCIENCE PROGRAM AS A TICK SURVEILLANCE AND PREVENTION EDUCATION TOOL

BY

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OF

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ABSTRACT

The multitude of factors fueling the escalation in tick-borne disease in the United States is further complicated by gaps in public knowledge and inconsistent adherence to tick-bite prevention behaviors. Passive tick surveillance is a growing strategy to monitor tick species trends and associated pathogen prevalence across the country. Most practice involves citizens shipping encountered ticks to a laboratory for identification and pathogen testing, but given potential delays in mailing and processing time, tick bite victims may be placed outside the window of potential prophylactic options, or under unnecessary antibiotic administration. Recently, photographed-based tick surveillance has been shown to be a viable alternative to in-hand specimen surveillance. We evaluated four years of data from a nationwide crowdsourced photographic tick surveillance program (TickSpotters) to examine its utility as both a tick identification and surveillance tool, as well as a channel to engage the public in health communication theory-based tick bite prevention education. We found that when compared to laboratory confirmed specimens, trained tick scientists could identify commonly encountered tick specimens by photograph submission with an overall accuracy of 96.7%. Photograph submissions to the system capture more than 50% of known county distribution of three ticks of human and veterinary medical relevance, and potentially detected hundreds more counties with newly described tick presence. Participant responses collected by the TickSpotters system suggested that the public demonstrates poor overall tick identification ability, particularly when it comes to nymph stage ticks and tick specimens that are highly-engorged. Pets appear to have ticks that feed on them for longer than those on humans, and pet owners report more tick encounters on their

pets in the colder months. When compared to Master Gardeners, TickSpotters users reported more frequently performed tick bite management strategies that are in line with science-based guidance, but both TickSpotters and Master Gardeners exhibited poor tick knowledge as well as inconsistent prevention behaviors. These results support the use of the TickSpotters program as a socioecological surveillance tool, and also reveal several areas requiring reassessment to improve the program's role in prevention educational interventions.

ACKNOWLEDGMENTS

I would like to express my heartfelt gratitude to my entire dissertation committee, with particular kudos to my advisor Dr. Tom Mather, for the collective guidance, wisdom, and assistance in this research journey. I could not have reached this point in my career without all of you.

To my unwaveringly supportive and loving spouse, Scott. There is absolutely no way I could have accomplished this without you. Thank you for your sacrifices, for your advice, and for loving me even when I was not loveable. Here's to Drs. KoPasichow!

To my dearest Sierra, whose curiosity, bravery, and spirit of adventure fill me with so much hope for the future. I hope that I've been and continue to be a strong role model. I am excited to be able to play more now.

To my family and friends who provided endless love, support, listening ears, and childcare: thank you. You have no idea how much you helped me get to this point, and I am so grateful.

This dissertation is dedicated to the memory of my father, John. Thank you for always believing in me and encouraging me to press on. I wish you were here to listen to me talk about my research until your eyes glaze over, just one more time. I love and miss you dearly.

PREFACE

Manuscript format is in use in this dissertation. There are five manuscripts in total to be submitted to the following academic journals:

Manuscript 1*: Crowdsourced photographs as an effective method for large-scale passive tick surveillance* is submitted to the Journal of Medical Entomology.

Manuscript 2: *Assessing public tick identification ability and tick bite riskiness using passive photograph-based crowdsourced tick surveillance* is to be submitted to the Journal of Medical Entomology.

Manuscript 3: *Tick biting trends on pets revealed by crowdsourced data* is to be submitted to Zoonoses and Public Health

Manuscript 4: *Examining the spatial distribution of photograph-based crowdsourced tick surveillance* is to be submitted to Ticks and Tickborne Diseases

Manuscript 5: *Tick-borne disease prevention behaviors among participants in a citizen science photograph-based passive tick surveillance system* is to be submitted to the Journal of Medical Entomology.

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Manuscript 1

Is submitted to the Journal of Medical Entomology

Crowdsourced photographs as an effective method for large-scale passive tick surveillance

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Abstract

As tick vector ranges expand and the number of tickborne disease cases rise, physicians, veterinarians, and the public are faced with diagnostic, treatment, and prevention challenges. Traditional methods of active surveillance (e.g. flagging) can be time-consuming, spatially-limited, and costly, while passive surveillance can broadly monitor tick distributions and infection rates. However, laboratory testing can require service-fees in addition to mailing and processing time, which can put a tick bite victim outside the window of potential prophylactic options, or under unnecessary antibiotic administration. We performed a retrospective analysis of a national photograph-based crowdsourced tick surveillance system to determine the accuracy of identifying ticks by photograph when compared to those same ticks identified by microscopy and molecular methods at a tick testing laboratory. Ticks identified by photograph were correct to species with an overall accuracy of 96.7% (CI [(0.9522, 0.9781)], $p < 0.001$), while identification accuracy for *Ixodes scapularis* Say*, Amblyomma americanum* Linnaeus, and *Dermacentor variabilis* Say*,* three ticks of medical importance, was 98.2% (Cohen's Kappa (κ) = 0.9575; 95% CI: [(0.9698, 0.9897)]), 98.8% (κ = 0.9466, 95% CI: [0.9776, 0.9941]), and 98.8% (κ = 0.9515, 95% CI: [0.9776, 0.9941]), respectively. Fitted general linearized models revealed that tick species and stage were the most significant predictive factors that contributed to correct photograph-based tick identifications. Neither engorgement, season, nor location of submission affected identification ability. These results provide strong support for the utility of photograph-based tick surveillance as a tool for risk assessment and monitoring among commonly encountered ticks of medical concern.

Introduction

Tick-borne disease is a widespread and growing public health problem in the United States. The Centers for Disease Control and Prevention (CDC) report that between 2004 and 2016, the incidence of tick-borne disease doubled and Lyme disease accounted for 82% of human cases (Rosenberg et al. 2018). Incidence of rickettsial diseases like anaplasmosis and ehrlichiosis has also risen (Dahlgren et al. 2011; Mogg et al. 2020). The documented increase in cases is dependent on numerous known and unknown factors, including improved surveillance and testing, but with one major contributor being the range expansion of disease-vectoring ticks. The two main Lyme-disease vectoring ticks, blacklegged (deer) ticks (*Ixodes scapularis* Say) in eastern and midwestern states and its western blacklegged counterpart (*Ixodes pacificus* Cooley & Kohls) increased their recorded county presence by 44.7% in the past 20 years (Eisen et al. 2016). Numerous sources of surveillance data also suggest that the Lone star tick (*Amblyomma americanum* L.), responsible for transmitting *Ehrlichia chaffeensis*, various other rickettsial species, and triggering a mammalian-meat consumption allergy, is spreading north- and westward (Springer et al. 2014; Christenson et al. 2017; Nelder et al. 2018; Sonenshine 2018; Jordan & Egizi 2019).

Long-term tick surveillance is an important method for tracking tick population distributions and the relative public health risk to humans and companion animals. Active surveillance, most often conducted using flagging, dragging, or chemical-attractant lure methods survey ticks directly in the field and can establish important disease risk metrics like density of nymphs and density of infected nymphs/entomological risk index for Lyme disease and other tick-borne pathogens

(Mather et al. 1996; Pepin et al. 2012; Johnson et al. 2018). However, these methods are often time, labor, and financially limiting. An alternative sampling strategy is passive surveillance in which tick specimens are submitted directly from the public or partnering agencies like hospitals, wildlife and veterinary clinics, and hunting stations (Lee et al. 2019). While often regarded as a less robust sampling method, passive tick collection provides wide spatio-temporal sampling reach and provides the ability to collect additional attributes regarding the behavior of humans, domestic, and wild animal hosts, pathogen infection prevalence and new disease detection (Ogden et al. 2006; Rand et al. 2007; Tulloch et al. 2017; Nieto et al. 2018; Xu et al. 2018; Xu et al. 2019; Porter et al. 2019). The use of passive submissions has been successfully shown to be a reliable measure of tick abundance, and was also shown to provide an accurate indication of human disease risk (Xu et al. 2016; Ripoche et al. 2018; Nieto et al. 2018).

Much fear exists within the public regarding Lyme disease, which is characterized to be a dangerous, insidious, and difficult to diagnose and treat infection (Aronowitz 1991; Herrington 2004; Auwaerter et al. 2011). This anxiety combined with a confusion regarding which tick species (*I. scapularis* and *I. pacificus* in North America) and stages (nymphs and adults) transmit the disease-causing bacteria have led to the belief that prophylaxis should be taken regardless of the duration and type of tick bite (Mather and Mather 1990; Auwaerter et al. 2011; Kopsco et al. *in review*). Current Infectious Disease Society of America recommendations suggest that simple species identification and feeding time assessment is enough to establish whether prophylaxis should be administered (Wormser et al. 2006), both of which can be easily provided by photographic surveillance. Additionally, photo-based submission can overcome the

limitations to submitting in-hand tick specimens, such as delays related to mailing and processing time, which can put a potential Lyme-disease-carrying tick bite victim outside the window of potential prophylactic options, or under unnecessary antibiotic administration and worry. However, inconsistencies in photo quality and similar-looking rare and more common ticks can potentially limit the accuracy and reliability of such a method. In the only study reported to date that examined the ability of trained researchers to identify tick species by photograph, Koffi et al. (2017) found that with proper photo quality, trained entomologists could prospectively identify commonly encountered ticks correctly to species with 97.2% accuracy (Kappa (κ) = 0.92, Z= 15.46, $p < 0.001$).

We sought to retrospectively examine the accuracy of tick identifications in a longstanding photo-based surveillance system by comparing ticks identified by photograph with those identified via microscopy with molecular confirmation. We hypothesized that tick photographs were identified correctly to species by trained tick researchers at least 90% of the time. It was expected that variables contributing to incorrect identifications included the life stage of the tick viewed, with nymphs resulting in a higher degree of incorrect identifications than adults, region of submission, and the researcher-expressed uncertainty in the identification (i.e. including in the response to the submitter that the photo is not clear enough to provide a definitive identification, but provides a suggested most likely option).

Methods

Data collection

We compared photograph submissions of tick species sent to TickSpotters, a passive surveillance program at the University of Rhode Island's TickEncounter Resource Center, to matched in-hand tick specimens sent to the TickReport program at the University of Massachusetts' Laboratory of Medical Zoology from 2015-2017. Included within the TickSpotters program response email is a suggestion for tick testing, and a link to the TickReport program submission page. Due to this connection, it was assumed that there would be a certain amount of overlap in tick submissions to both programs.

The TickReport program provides tick identification and pathogen testing services. They collect mailed tick specimens and record a preliminary species and stage identification during microscopic examination of both the dorsal and ventral surfaces of the tick. Identification to species level is confirmed using real-time quantitative polymerase chain reaction, and equivocal results are resolved with DNA sequencing.

For tick surveillance purposes and assistance in photograph identification, the TickSpotters program asks participants to include with their photograph the date when the tick was discovered, the most reasonable zip code of encounter, whether there was any travel history in the previous five days, and whether the tick was found on a person, pet, or loose in the home. A section for more elaboration on the encounter is also included on the submission form. Upon identifying the tick to species and stage, TickSpotters also estimates the engorgement status by comparison with pictures of ticks removed from hosts whose duration of attachment was determined using the scutal

index (Yeh et al. 1995) to provide a risk assessment in the responding e-mail. If a tick cannot be identified to species via photograph due to photo quality, an email is sent requesting an additional image, and the tick is classified as "Unknown" unless a more definitive identification is made upon receipt of a higher quality photograph. TickSpotters data collection is approved and overseen by the University of Rhode Island Institutional Review Board.

Comparing datasets

We examined the distribution of overlapping submissions between TickSpotters and TickReport to identify the most common region of submission, the species and stage of ticks submitted, the engorgement status using estimates based on the scutal index (Yeh et al. 1995), and the season of submission. A matched TickSpotters photo/TickReport in-hand submission was defined as any entry within the time period that had the same email address and was submitted to both programs within 48 hours to conservatively match tick photos to mailed-in tick specimens. However, we recognize that these criteria still allowed for the possibility that the photograph sent to TickSpotters was not of the same tick that was sent to TickReport, resulting in a potential mismatch of photo and in-hand specimen results. Cross-referencing of matched submissions was conducted as carefully as possible, but there may have been an insignificant number of false negatives or false positives.

For TickSpotters accuracy assessment, photo-based identification was incorrect when the TickSpotters-determined genus, species or both did not match the TickReport record. When a photo was too blurry or did not include the proper lighting to be

identified, an additional photograph was requested. If a clearer photograph was not sent or the specimen was still unidentifiable by TickSpotters researchers, these entries were called “Unknown” and classified as “Incorrect” identifications due to a “failure” for the system to be able to identify from a photograph. If a TickSpotters researcher made a “most likely” identification call but was not entirely certain without further photographic clarification (denoted in the TickSpotters response with question marks), the identification included a binary “Certain” or “Uncertain” score, and this variable was included as a separate covariate in the model.

Statistical analysis

Using TickReport identification as the reference value and the TickSpotters identification as the test value, we performed a classification accuracy analysis to test the hypothesis that over 90% of the TickSpotters identifications (test) matched the TickReport identifications (reference). This was performed by establishing a confusion matrix to calculate the overall proportion of correct photograph identification to incorrect, as well as sensitivity, specificity, and positive and negative predictive values. We then used the same test for *I. scapularis, A. americanum,* and *D. variabilis* submissions individually to establish the level of accuracy for these three species of particular medical concern and range expansion out of the entire dataset. We used Cohen’s Kappa statistic to evaluate the inter-rater reliability between TickReport and TickSpotters tick identifications. Using a scale of 0-1, Cohen’s Kappa reports how well the test classifier (i.e. TickSpotters identification) is performing against the reference value (i.e. TickReport identification) beyond random chance (Landis et al. 1977). We

opted for this method over simply looking at the percentage correct for each class of tick species because classification accuracy can be misleading in the event of unequal numbers of observations, as was the case for these data. A confusion matrix using Cohen's Kappa incorporates errors such as false negative and false positives into the performance prediction (Landis et al. 1977).

To model the probability of a correct tick identification by photograph we fit a logistic regression, a generalized linear model (GLM) that connects a binary outcome to a set of predictors using a logit link function (**Equation 1**). Out of a set of eight covariates we investigated the possible predictive factors involved with a correct tick photograph identification. These covariates were: encounter season, tick species, tick life stage, engorgement or feeding status (days), uncertainty (binary measure) of researcher in the identification based on the photograph quality, state of encounter (fine spatial scale), region of encounter (broad spatial scale), and host (either loose and wandering, on a pet, or on a person).

Equation 1.

$$log\left(\frac{p(X)}{1-p(X)}\right) = \beta_0 + \beta_1 X_1 \dots \beta_8 X_8$$

Where, the log odds, or probability (**p**), that a tick is identified correctly (***X***), is equal to the coefficients ($\beta_0 + \beta_1 \dots \beta_8$) multiplied by the values of the eight covariates as mentioned above. ($X_1 \dots X_8$). The log odds increase or decrease according to a one-unit change in ***X.***

Training and testing datasets were established by randomly selecting 400 observations, and models were evaluated considering several combinations of

parameters using Akaike's Information Criterion (AIC) and Bayesian Information Criterion (BIC), commonly used model selection criterion on the training data set. Upon selection of the top optimal models using information criterion, we performed additional model fitting using McFadden's pseudo R, Hosmer and Lemeshow goodness of fit test for risk prediction and calculated a receiver operator curve (ROC) on the testing dataset. Computation and analysis were performed in R version 3.6.1/RStudio version 1.2.1335.

Results

Between January 2015 and December 2017, 816 overlapping records of tick photos and in-hand tick specimens were submitted to TickSpotters (3.83% of all submissions during this period) and TickReport (3.50% of all submissions during this period), respectively. Of the total submissions during this time period, TickReport received 74.7% *Ixodes* spp., 14.5% *Dermacentor* spp., 9.7% *Amblyomma* spp., and 1.1% other tick species or specimens. TickSpotters pool of submissions comprised 34.8% *Ixodes* spp., 34.8% *Dermacentor* spp., 17.0% *Amblyomma* spp., 2.3% *Rhipicephalus* spp., while other specimens that included unidentifiable ticks, rare ticks, and non-tick arthropods made up 11.1% of all photo submissions (**Fig. 1**). Submissions compared were sourced predominantly from northeastern and mid-Atlantic states (67% were from Massachusetts, New York, Pennsylvania, Rhode Island, New Jersey, Maryland, and Connecticut collectively).

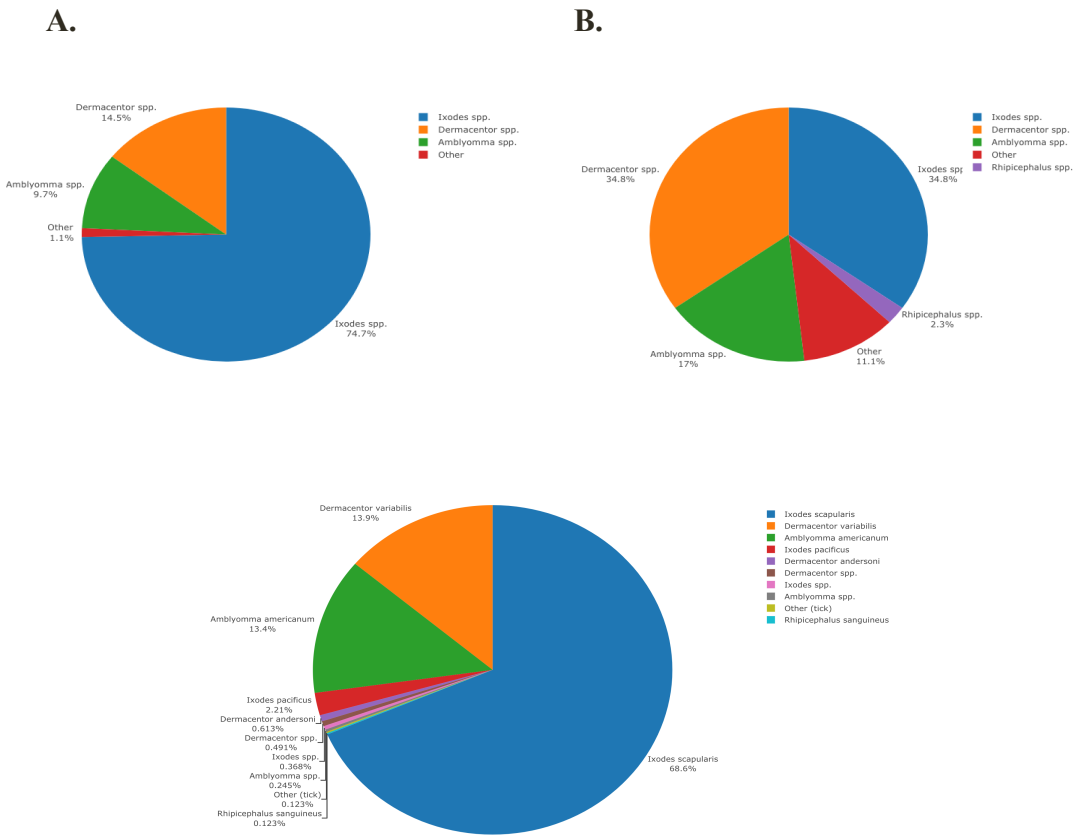

Fig. 1. Proportional tick species contribution to the overall submission pool for both TickReport and TickSpotters during the period from which the overlapping sample was taken (January 1, 2015 through December 31, 2017). **A**. TickReport (n=23,379), **B**. TickSpotters (n=21,287), **C**. Overlapping matched sample (n=816) of tick submissions that were sent to both TickReport and TickSpotters and was used for TickSpotters accuracy analysis (according to identifications from TickReport).

Table 1. Demographics of overlapping TickSpotters and TickReport submissions from January 2015-December 2017 (n=816).

Variable	Categories	No. (%)
Region of residence	Northeast (ME, NH, VT, MA, RI, CT, NY, PA, NJ)	576 (70.4%)
	Southeast (DC, DE, MD, VA, WV, NC, SC, GA, FL, AL, TN, KY, MS, LA, AR)	121 (14.8%)
	Midwest (MO, OH, IN, MI, IL, WI, MN, IA, KS, NE, SD, ND)	84 (10.3%)
	Pacific (WA, OR, CA)	28 (3.4%)
	Mountain (MT, CO, WY, UT, ID, NV)	5 (0.6%)
	Southwest (OK, TX, NM, AZ)	4 (0.5%)
Tick Species Submitted	*Ixodes scapularis* *Dermacentor variabilis* *Amblyomma americanum* *Ixodes pacificus* *Dermacentor andersoni* *Dermacentor spp.* *Ixodes* spp. *Amblyomma* spp. *Rhipicephalus sanguineus* Other (tick)	560 (68.6%) 114 (13.9%) 110 (13.4%) 18 (2.21%) 5 (0.613% 4 (0.491%) 3 (0.368%) 2 (0.245%) 1 (0.123%) 1 (0.123%)
Stage of Tick Submitted	Adult Nymph Unknown Larva	609 (74.6%) 187 (22.9%) 13 (1.6%) 7 (1.0%)
Tick Engorgement (Days)	Unfed to less than 1 day fed 1-3 days fed 3.5-5 days fed > 5 days	240 (29.3%) 384 (46.9%) 177 (21.6%) 18 (2.2%)
Tick Host	Human Domesticated animal Loose and wandering	740 (90.6%) 55 (6.7%) 21 (2.7%)
Season of Submission	Spring (Mar. 1- May 31) Summer (Jun 1 - Aug 31) Fall (Sept. 1 - Nov. 30) Winter (Dec. 1 - Feb 28)	296 (36.2%) 233 (28.5%) 228 (27.9%) 59 (7.2%)

Tick species represented commonly encountered North American ticks of human and domestic animal concern, with *I. scapularis* representing 68.5% of ticks submitted to both services, followed by *D. variabilis* (13.8%), *A. americanum* (13.4%), *I. pacificus* (2.20%), *D. andersoni* Stiles (0.61%), *Dermacentor* spp. (0.48%), *Ixodes* spp. (0.36%), *Amblyomma* spp. (0.24%), *R. sanguineus* Latrielle (0.12%), and less common tick species (0.12%) (**Table 1**). While TickSpotters received a broader array of species submission. These proportions matched those received by TickReport during the same time period. Adult ticks comprised 74.6% of submitted specimens, while nymphs (22.9%) and larvae (0.85%) were considerably less commonly submitted. Stage could not be determined for 1.6% of ticks submitted by photograph (**Table 1**). Ticks submitted were mostly unfed (median engorgement = 1.5 days) but demonstrated a bi-modal distribution with peaks at 0 days (unfed), and 3 days (partially fed), and a maximum fed time at 8 days. *I. scapularis* comprised more than half of the reported ticks found to be feeding for 3, 3.5, and 4 days. Ticks submitted to both services were predominantly found on humans (90.6%), followed by pets (6.7%), and those found loose and wandering (2.5%) (**Table 1**). Ticks were submitted mostly in the spring (36.2%), with summer (28.5%) and fall (27.9%) having nearly identical submission rates, and winter (7.2%) being the least common season for submissions. *I. scapularis* was the most common overlapping tick submitted during all seasons, and this species made up nearly all of tick submissions in the fall and winter months.

TickSpotters Photo Identification Accuracy Analysis

Overall, the TickSpotters researchers correctly identified ticks to species from photos with 96.3% accuracy (789/818; CI (0.9495, 0.9761), p = 1.99e-07). The 30 incorrect identifications included six submissions with poor photo quality that we determined as "Unknown" (**Table 2**). When examining species of particular disease concern for humans and pets, identification accuracy was highest for *A. americanum* (98.6%; CI (0.9761– 0.9933); p < 0.001) (**Fig. 2**), followed by *Dermacentor* species (**Fig. 4**) including *D. variabilis*, *D. occidentalis* Marx, and *D. andersoni*, (98.6%; CI (0.9761 – 0.9933); p < 0.001) and *I. scapularis* (97.9%; CI (0.9669 – 0.9878); p < 0.001) (**Fig. 3**) (**Table 3**).

The most commonly misidentified tick species occurred in order of their proportional representation, with *I. scapularis* misidentified by TickSpotters the most (11 misidentified ticks; 1.96% of all *I. scapularis* received), and most frequently identified as "Unknown" (**Table 2**). Both *A. americanum* (7 misidentified, 5.83% of all *A. americanum* received) and *D. variabilis* (5 misidentified, 4.39% of all *D. variabilis* received) were most often misidentified as *I. scapularis* (**Table 2**).

Table 2. Ticks incorrectly identified by photograph through the TickSpotters program (n=30). from January 2015 and December 2017.

Tick Species	Number of Missed Identifications (% total of species)	Percent of overall sample (n = 816)	Most Commonly Misidentified As
Ixodes scapularis (n = 560)	11 (1.96%)	1.34%	Unknown
Amblyomma americanum (n = 120)	7 (5.83%)	0.86%	*Ixodes scapularis*
Dermacentor variabilis (n = 114)	5 (4.39%)	0.61%	*Ixodes scapularis*
Amblyomma spp. (n = 2)	2 (100%)	0.25%	*Amblyomma americanum*
Rhipicephalus sanguineus (n = 1)	1 (100%)	0.12%	*Amblyomma americanum*
Ixodes pacificus (n =18)	1 (5.55%)	0.12%	*Rhipicephalus sanguineus*
Ixodes spp. (n = 3)	1 (33.3%)	0.12%	*Rhipicephalus sanguineus*
Dermacentor spp. (n = 4)	1 (25%)	0.12%	*Dermacentor variabilis*
Other tick (n = 1)	1 (100%)	0.12%	*Rhipicephalus sanguineus*

Table 3. TickSpotters photograph tick identification confusion matrix accuracy analysis for *A. americanum (*n=120), *I. scapularis* (n=560) and *Dermacentor spp*. (n = 123).

	A. americanum **(n=120)**	***I. scapularis*** **(n=560)**	***Dermacentor spp.*** **(n= 123)**
Accuracy	0.9866	0.9792	0.9866
95% Confidence Interval	(0.9761, 0.9933)	(0.9669, 0.9878)	(0.9761, 0.9933)
P-value	< 0.001	< 0.001	< 0.001
Kappa	0.9416	0.9522	0.9472
Sensitivity	0.9364	0.9786	0.9512
Specificity	0.9944	0.9806	0.9928
Positive Predictive Value	0.9626	0.9910	0.9590
Negative Predictive Value	0.9902	0.9547	0.9914
Prevalence	0.1345	0.6846	0.1491
Detection Rate	0.1259	0.6699	0.1430
Balanced Accuracy	0.9654	0.9796	0.9720
AUC	0.98	0.98	0.98

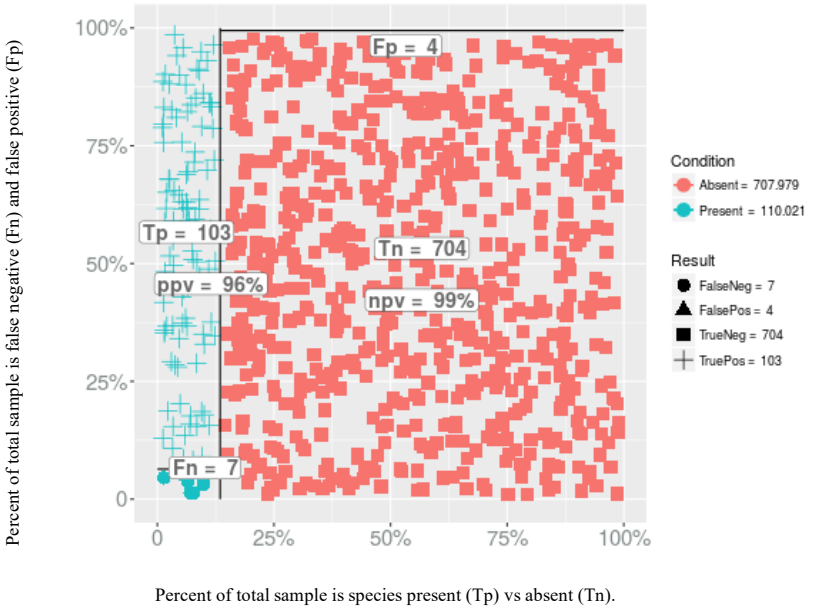

Fig. 2. Specificity and sensitivity analysis of TickSpotters photo-based identification of *A. americanum* encounters (n=120). The number of false positives, true positives, false negatives, and true negatives in relation to the overall abundance of *A. americanum* in the overlapping submission sample (absent *A. americanum* = another tick species versus present = *A. americanum*) are shown as identified by TickReport. Each tick included in the analysis is represented by one of the symbols in the legend, but do not connote a percentage individually. The totality of the space occupied by the symbols, separated by black lines represents the percent of the total sample of all ticks. Proportions of absent (Tn) versus present (Tp) are along the x-axis, while proportions of Fn vs Tp, and Fp vs Tn can be found on the y-axis. (Produced in shinyApp by Allen et al. 2017).

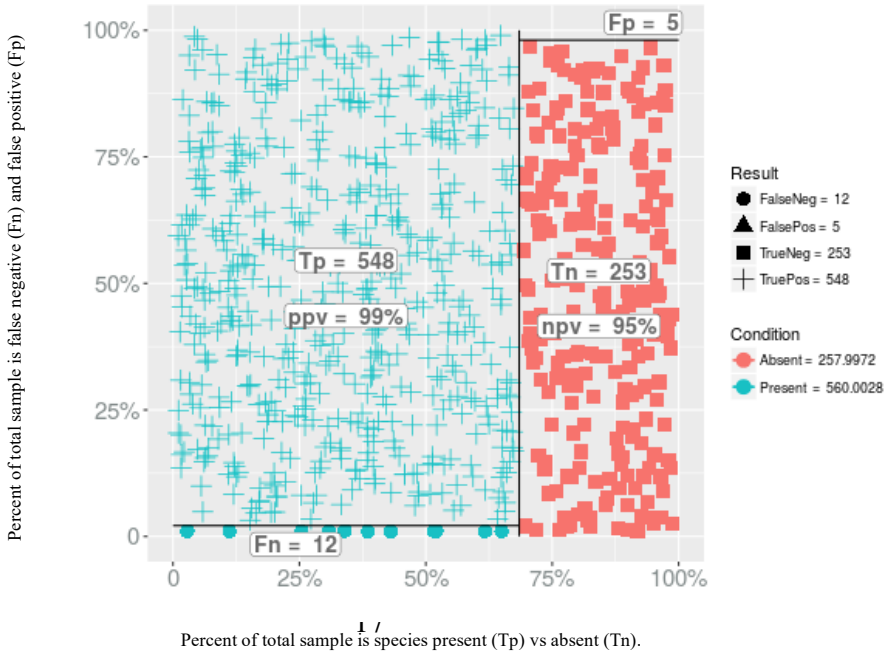

Fig. 3. Specificity and sensitivity analysis of TickSpotters photo-based identification of *I. scapularis* encounters (n=560). The number of false positives, true positives, false negatives, and true negatives in relation to the overall abundance of *I. scapularis* in the overlapping submission sample (absent *I. scapularis* = another tick species, versus present = *I. scapularis*) are shown as identified by TickReport. Each tick included in the analysis is represented by one of the symbols in the legend, but do not connote a percentage individually. The totality of the space occupied by the symbols, separated by black lines represents the percent of the total sample of all ticks. Proportions of absent (Tn) versus present (Tp) are along the x-axis, while proportions of Fn vs Tp, and Fp vs Tn can be found on the y-axis. (Produced in shinyApp by Allen et al. 2017).

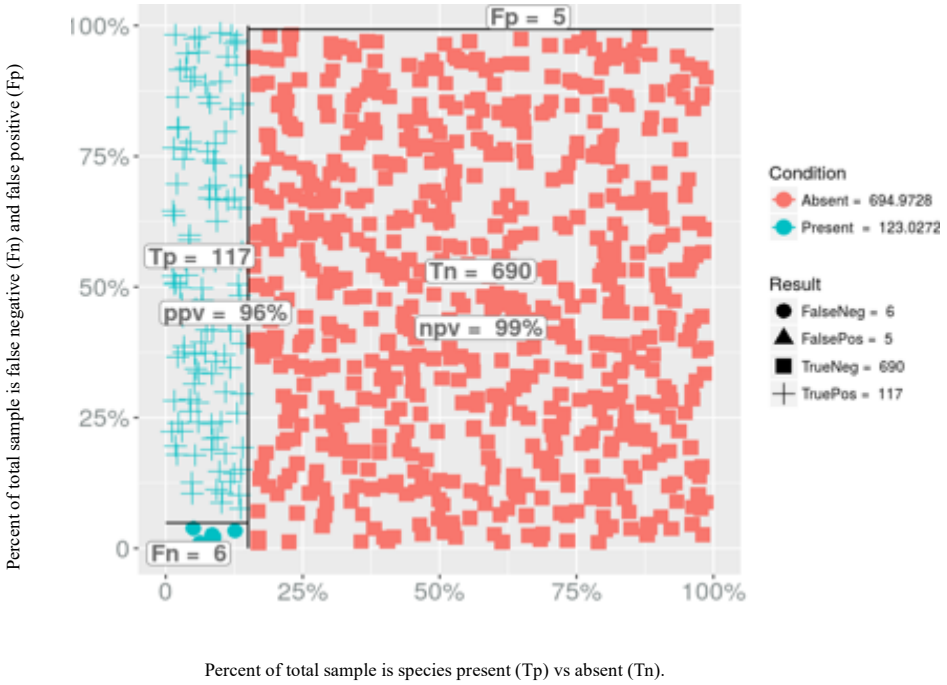

Fig. 4. Specificity and sensitivity analysis of TickSpotters photo-based identification of *Dermacentor spp.* encounters (n=123). The number of false positives, true positives, false negatives, and true negatives in relation to the overall abundance of *I. scapularis* in the overlapping submission sample (absent *Dermacentor spp.* = another tick species, versus present = *Dermacentor*) are shown as identified by TickReport. Each tick included in the analysis is represented by one of the symbols in the legend, but do not connote a percentage individually. The totality of the space occupied by the symbols, separated by black lines represents the percent of the total sample of all ticks. Proportions of absent (Tn) versus present (Tp) are along the x-axis, while proportions of Fn vs Tp, and Fp vs Tn can be found on the y-axis. (Produced in shinyApp by Allen et al. 2017).

Logistic regression model for covariates associated with identifying a tick by photograph

Based on the distribution of the data and binary outcome (i.e. correct or incorrect tick identification), a logistic regression was fitted. After examining models containing several combinations of parameters and comparing them to the null (intercept only) model, the model incorporating tick species and tick stage as predictors was selected as optimal using both AIC and BIC (**Table 4**).

Table 4. General linearized model summaries for the five top performing models predicting tick identification accuracy by photograph. The model incorporating the covariates of tick species (Spp), life stage (Stg) was the most predictive of tick identification by photograph and chosen as the optimal model. Coefficients are listed with the standard errors in parentheses below. Significant p-values are listed and coded according to the number of asterisks (see footnote).

	Spp+Stg	Spp+Stg+Reg	Spp+Stg+Reg+Uncert	Spp+Stg+Reg+Uncert	Spp+Stg+Sea+Reg
(Intercept) (Species: *Ixodes scapularis*, Stage: Adult Researcher certainty: Certain Region: Northeast Season: Spring	**7.61** *** **(1.52)**	7.90 *** (1.68)	8.09 *** (1.69)	7.77 *** (1.80)	8.38 *** (1.84)
Species: *Dermacentor variabilis*	**-4.25** ** **(1.45)**	-4.56 ** (1.63)	-4.73 ** (1.68)	-5.12 ** (1.87)	-5.05 ** (1.84)
Species: *Amblyomma americanum*	**-0.00** **(1.29)**	-0.10 (1.31)	0.02 (1.47)	-0.35 (1.72)	-0.08 (1.51)
Species: *Ixodes pacificus*	**13.11** **(2846.21)**	13.16 (2801.27)	-7.05 (4511.27)	-6.87 (33098.78)	-6.83 (4485.81)
Species: Other	**-6.32** *** **(1.77)**	-6.65 *** (1.90)	-25.43 (3538.43)	-30.98 (26287.60)	-25.72 (3534.97)
Species: *Amblyomma* spp.	**-22.43** **(6522.64)**	-22.33 (6522.64)	-58.40 (9879.78)	-72.90 (73053.23)	-58.29 (9878.54)
Stage: Nymph	**-3.75** ** **(1.35)**	-4.15 ** (1.55)	-4.17 ** (1.46)	-5.07 ** (1.75)	-4.56 ** (1.66)
Stage: Larva	**-6.51** *** **(1.86)**	-7.15 ** (2.22)	-7.12 *** (2.09)	-25.00 (3350.62)	-7.71 ** (2.40)
Uncertainty: Uncertain		0.80 (1.36)			0.73 (1.37)
Region: Southeast			-0.43 (1.33)	0.17 (1.48)	-0.37 (1.35)
Region: Midwest			0.54 (1.52)	0.17 (1.54)	0.65 (1.60)
Region: Pacific		(3538.43)	20.05 (26287.60)	25.00 (3534.97)	19.89
Region: Mountain		(7420.60)	35.91 (54899.05)	45.78	35.91 (7418.95)
Region: Southwest		(3531.03)	14.10 (25282.85)	19.08 (3520.36)	14.30
Season: Summer				1.86 (1.23)	
Season: Autumn				35.47 (4562.15)	
Season: Winter				14.63 (8468.02)	
AIC	**65.15**	66.77	70.47	68.39	72.15
BIC	**96.84**	102.42	121.96	131.76	127.61
Log Likelihood	**-24.57**	-24.38	-22.23	-18.19	-22.08
Deviance	**49.15**	48.77	44.47	36.39	44.15
Num. obs.	**388**	388	388	388	388

*** p < 0.001, ** p < 0.01, * p < 0.05
Optimal model results are bolded
Spp = Species; Stg = Stage; Sea = Season; Reg = Region; Uncert = Researcher certainty in ID
Other = unidentifiable ticks, rare ticks, and non-tick arthropods

The optimal model (tick species and life stage) produced both the lowest AIC and BIC scores relative to the other models. Adding interactions between the two

predictors within this model did not improve model fit. The Wald test revealed that both tick species and stage are significant covariates within the top model, and while McFadden's pseudo R for this model was the smallest among models assessed (0.32; range = 0.32-0.46), an R^2 value between 0.2 and 0.4 indicates excellent fit (Domencich and McFadden 1996). Within 20 iterations, there were no statistically significant values ($p < 0.05$) returned in Hosmer and Lemeshow goodness of fit (GOF) tests, indicating that there was no significant difference between the observed data and the values that were predicted by the model. The receiver operator curve (ROC) for the species+stage model reflected an area under the curve (AUC) of 0.919, which was the largest AUC of any of the models examined (**Fig. 5**). These results suggest that the two parameters included in the model demonstrate strong predictive power for explaining the factors influencing tick identifications by photograph.

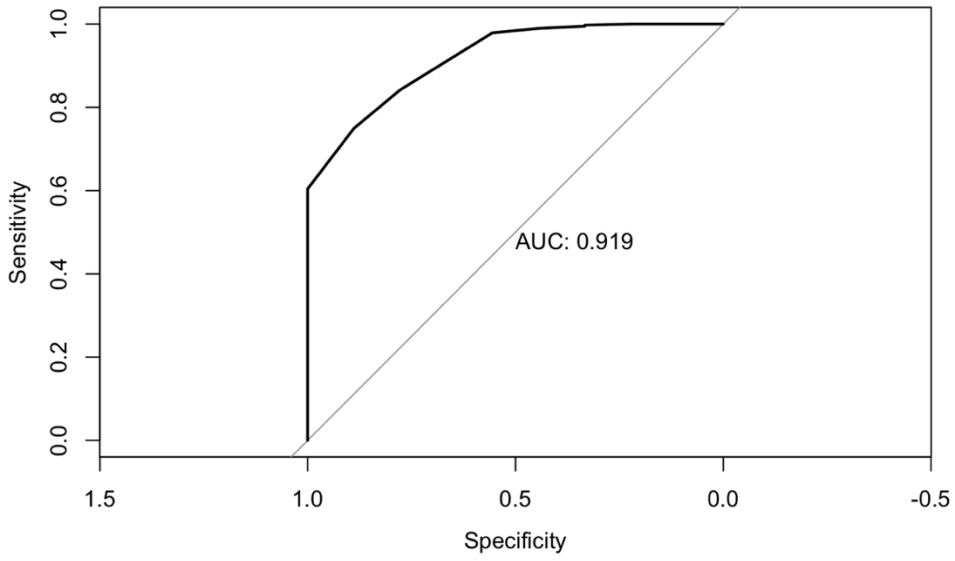

Fig. 5. Receiver operator curve (sensitivity (true positives) versus 1- specificity (false positives)) for the optimal model incorporating species, stage, season, and region as predictors for a correct tick identification by photograph, reporting an area under the curve (AUC) of 0.919, suggesting that this model predicts the ability to identify a tick with excellent sensitivity.

Discussion

Citizen science, or when scientists engage the public in data collection and other aspects of research projects, is an increasingly popular method for vector-borne disease surveillance. Across Europe, the Mosquito Alert program, designed to employ the public to help track the invasion of Asian tiger mosquitoes (*Aedes albopictus*) found that engaging citizens for data collection can provide an economical and scalable method for collecting surveillance data (Palmer et al. 2017). Similarly, utilizing digital and app-based programs have allowed scientists to recruit citizens in monitoring tick activity in Lyme disease-emergent areas like parts of southern Canada (Hines and Sibbald 2015; Lewis et al. 2018). In the United States, Nieto et al. (2018) established a nationwide tick and pathogen surveillance that identified new foci of disease and tick distribution, and inexpensively monitored tick risk and encounter demographics throughout highly tick and Lyme-endemic northeastern states (Porter et al. 2019). The TickReport program is one of the few services that provides tick species and pathogen testing results to the public in addition to aggregating and interpreting the passively collected data (Xu et al. 2016). Each of these methods, however, relies on the collection and processing of specimens which can leave participants who encountered a biting tick often waiting several days for a species confirmation.

Similar to a prospective surveillance analysis (Koffi et al. 2017), we found that tick photographs that include adequate lighting and focus to visualize key anatomical features including the scutum, palps, number of legs, degree of engorgement (i.e. scutum:body ratio) can be correctly identified to species by trained tick experts more than 90% of the time. According to the optimal model, TickSpotters identification

accuracy is dependent on ticks being among the nine most commonly encountered species and life stage, and was not confounded by region of the country, season of submission, or engorgement of the photographed tick. While these finding support the reliability of tick identification by photograph, modeling results underscore the importance of including size references in tick photographs, as nymphs and larvae were significantly less likely to be identified correctly than adult ticks. Knowledge of travel history also is critical for a photographic surveillance system to remain reliable given the similar-looking tick species that occur in different parts of the country (e.g. *I. scapularis* and *I. pacificus*) and is why TickSpotters includes a question regarding travel on its submission site. For example, in 2016 after the United States eased travel restrictions to Cuba, TickSpotters started getting out-of-season submissions of partially-engorged nymph stage *Amblyomma* ticks from states where *Amblyomma* are not known to occur. In four cases, questioning travel history revealed recent returns from Cuba, where *Amblyomma cajennense* is common encountered. Querying recent travel history can also be critical for tracking tick trends; one Colorado TickSpotter found a three to four-day engorged adult female Asian longhorned tick (*Haemaphysalis longicornus*) on his dog, but we learned he had been in New Jersey with the dog three days before he found the tick.

Submission of digital photographs of ticks allows rapid (24 hours or less) responses containing public health assurance of likely disease risk, and best next steps for appropriately managing the current tick encounter and helping prevent future tick bites. Among the most commonly encountered ticks in North America, disease risk and the pathogens transmitted by tick bite vary greatly. While blacklegged and western

blacklegged ticks are competent vectors of Lyme disease bacteria, other tick species, including American dog ticks and Lone Star ticks are not (Mather and Mather 1990; Stromdahl et al. 2018). Unfortunately, this fact is not widely appreciated or acknowledged by the general public, who frequently are anxious about risk of a Lyme disease infection (Auwaerter et al. 2011; Fogel and Chawla 2017). If not quickly informed about the correct tick identification and possible disease associations, citizens will seek and medical professionals will potentially treat tick bites unnecessarily with antibiotics. Given the increasing problem of antibiotic resistance (Ventola 2015), avoiding unnecessary prophylactic treatment of any length is critically important. Further, properly identifying when a specific tick species was encountered within the window for prophylaxis or prior to disease symptoms manifesting can help prevent prolonged or delayed medical testing and additional associated medical costs (Adrion et al. 2015). In light of recent evidence showing differences in pathogen transmission dynamics between the two main Lyme disease vectors in the United States (Couper et al. 2020), a photo-based surveillance system is also a potential avenue for rapid communication regarding risk levels encountered.

There are some limitations with this specific study as well as being inherent to this method of accurately identifying ticks from photographs. Both TickReport and TickEncounter received predominantly three tick species (*I. scapularis*, *D. variabilis*, and *A. americanum*). We recognize that by chance, identification accuracy could be falsely inflated by the increased likelihood of one of these three ticks being the correct identification. However, we used a classification accuracy analysis to mitigate this potential bias, as this method corrects for imbalance in sample proportions for

determining accuracy, sensitivity, and specificity (Dziak et al. 2012). More rarely encountered ticks, or ones that appear visually similar within overlapping ranges (e.g. *D. variabilis* and *D. andersoni* in the western U.S.) were more likely to be incorrectly identified than ticks with more distinct ranges and appearance. Contextual parameters, most importantly geographic location and travel history, but also providing a recognizable size reference, and occasionally seasonality are needed to help ensure an accurate tick identification when using photographs. Photos provided without these key pieces of information may limit the ability to correctly identify less commonly occurring ticks, or new imports. However, this is not only a critique of photo-based identification. Despite microscopy, *Haemaphysalis longicornis* was misidentified as the native *Haemaphysalis leporispalustris* for decades until a massive infestation on a New Jersey farm in 2017 (Rainey et al. 2018) brought their presence to light. Short of molecular identification, visual identification alone can be mistaken if one is simply not expecting something new. A likely lesser limitation, as explained above, was the chance that the photograph identified by TickSpotters was not the same tick ultimately mailed into and identified by TickReport. Cross-referencing of matched submissions was conducted as carefully as possible (same email address within 48 hours) but there may have been an insignificant number of false negatives or false positives. The fact that both services received different proportions of tick species suggests that our identification accuracy is not simply based on random chance due to the similarity of the samples. Finally, TickSpotters often receives photo specimens of non-tick arthropods or things that citizens believe are ticks (roughly 5% of submissions), but there were no matching submissions of non-tick specimens from TickReport to include in this analysis,

therefore not-a-tick identification ability could not be verified. Nevertheless, results from this study indicate that photo-based tick surveillance conducted by entomology experts is a valid and accurate method for rapid identification of commonly encountered ticks regardless of engorgement and can provide an important public health service in response to a significant and growing tick-borne disease incidence.

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Manuscript 2

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Assessing public tick identification ability and tick bite riskiness using passive photograph-based crowdsourced tick surveillance

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Abstract

Tick identification is important in assessing disease risk from tick bite, and citizen science systems can assist the public with tick identification. Data from the University of Rhode Island's TickEncounter Resource Center's photo-based surveillance system, TickSpotters, indicate that users incorrectly identified or opted to not identify their submitted specimen 83% of the time. Of the top four most commonly submitted tick species, western blacklegged ticks (*Ixodes pacificus* Cooley & Kohls) had the largest proportion of unidentified or misidentified submissions (87.7% not identified correctly to species), followed by Lone star ticks (*Amblyomma americanum* L.; 86.8% incorrect), American dog ticks (*Dermacentor variabilis* Say; 80.7% incorrect), and blacklegged (deer) ticks (*Ixodes scapularis* Say; 77.1% of incorrect). More than one quarter of participants (26.3%) submitted photographs of ticks that had been feeding for at least 2.5 days, suggesting heightened risk. Logistic regression GLM suggests that participants were significantly more likely to misidentify nymph stage ticks than adult ticks (OR = 0.40, 95% CI: (0.23, 0.68), p <0.001) ticks. Ticks reported on pets were more likely to be identified correctly than those found on humans (OR = 1.07, 95% CI: (1.01-2.04), p <0.001), and ticks feeding for 2.5 days or more were more likely to be misidentified than those having fed for one day or less (OR = 0.43, 95% CI: (0.29-0.65), p <0.001). State and region of residence and season of submission did not contribute significantly to the ability to identify a tick correctly. These findings provide targets for future educational efforts and underscore the value of photograph-based tick surveillance to elucidate these knowledge gaps.

Introduction

Incidence of tick-borne disease has increased steadily across the United States in the past decade, with the number of reported cases of tickborne diseases doubling (Rosenberg et al. 2018). Research suggests that there are more than 300,000 new cases of Lyme disease each year, and although 95% of cases are reported from only 14 states (Diuk-Wasser et al. 2012; CDC 2019), it is still the most common vector-borne disease in the country, currently comprising 82% of all reported tickborne disease cases (Rosenberg et al. 2018). Health economists estimate that the current cost of Lyme disease to the U.S. healthcare system alone is between $712 million and $1.3 billion annually (Adrion et al. 2015). Reports of other tick-borne illnesses like babesiosis, ehrlichiosis, Rocky Mountain Spotted Fever, and various encephalitic viruses have doubled and tripled as their tick vector ranges expand (Springer et al. 2015; Eisen et al. 2016; Dahlgren et al. 2016; Rosenberg et al. 2018). Aside from direct healthcare costs, the uptick in these illnesses is also having indirect mortalities such as a rise in babesia-infected blood bank reserves that have resulted in ~30% fatality rates in transfusion patients who have received contaminated blood products (Lobo et al. 2013). The factors contributing to more cases of tickborne diseases are complex and include broad ecological changes like changes in climate and land use patterns (Hall et al. 2002; Guerra et al. 2002; Allan et al. 2003; Brownstein et al. 2005; Tran et al. 2013; Salkeld et al. 2015; Ostfeld and Brunner 2015; Gilliam et al. 2018), an increase in deer and other wildlife populations overlapping with human-inhabited space (Ginsberg et al. 1999; Rand et al. 2003; White et al. 2018), changes in human behavior that have resulted in enhanced exposure risks (Zeimes et al. 2014; Fischhoff et al. 2019), and overall improvements in disease diagnosis, surveillance, and reporting (Beard & Strickman 2014; Marques et al. 2015).

Despite widespread education initiatives in tick-endemic regions, numerous studies have shown that overall public perception and knowledge surrounding tick identification, tickborne disease risk, and proper disease prevention strategies is low (Herrington 2004; Bayles et al. 2013; Valente et al. 2014; Hook et al. 2015; Butler et al. 2016). Recommended tick bite prevention strategies include daily tick checks, vigilant use of effective personal repellent products with permethrin, picaridin, or DEET, area-wide yard sprays, and host-targeted acaricides (Eisen and Dolan 2016). There is a constant need for improved strategies capable of bolstering prevention behaviors given that the ranges of tick species and their associated diseases are changing, creating the increased potential for human risk in locations where there was recently little to none (Springer et al. 2014; Zeimes et al. 2014; Hahn et al. 2016). Some studies have found certain predispositions that individuals use in determining the need for preventative behaviors. Generally, preventative behaviors tend to increase when there is perceived risk of acquiring a tickborne disease, a person has a friend or family member with a tickborne disease, when a person has knowledge about a tickborne disease, and when a person believes a tickborne disease to be a serious problem (Herrington et al. 1997; Butler et al. 2016; Niesobecki et al. 2019). However, a nationwide survey of people across the United States found that even when awareness of tickborne illnesses is widespread, accurate knowledge is poor, and prevention measures are not routinely taken (Hook et al. 2015) even in Lyme-endemic regions (Niesobecki et al. 2019).

Although generally failing to take consistent preventative measures against tick bites, the public is nevertheless quite fearful of contracting a tickborne illness (Herrington et al. 2004; Gould et al. 2008; Fogel and Chawla 2017; Niesobecki et al. 2019; Kianersi et al. 2020). Lyme disease, in particular, is steeped in confusion and conspiracy theories,

fueled by misinformation rampant on social media and internet sites, (Basch et al. 2017; Aguero-Rosenfeld and Wormser 2015; Irving et al. 2019; Journault et al. 2019) that has sown distrust in the scientific community (Aronowitz 1991; Auwaerter et al. 2011; Kopsco et al. *in review* a). Due to this tick anxiety, people often consult their primary care physicians, pediatricians, or emergency physicians at emergency departments to remove ticks or for antibiotics immediately after a tick bite (Daly et al. 2017; Applegren and Claus 2017). However, physicians are frequently just as poor at providing a proper tick species identification as the public (Falco and Fish 1998; Butler et al. 2017). Due to the wide variety of tick-specific pathogens across the country, and the dependence of life stage on disease risk, the ability to correctly identify a tick is a crucial part of managing a tick bite for tickborne disease prevention. The Infectious Disease Society of America recommends prophylaxis antibiotics to be administered in the event that an adult or nymphal *Ixodes scapularis* Say has been attached for 36 hrs. or longer, which can be determined using the scutal index (Yeh et al. 1995; Kelly et al. 1999; Wormser et al. 2006; Falco et al. 2018). However, if the tick species is not known, antibiotics may be either administered or withheld unnecessarily.

Passive surveillance is a validated and widely employed tool to estimate and observe changes in tick abundances, disease prevalence, and habitat range (Rand et al. 2007, Nelder et al. 2014; Xu et al. 2016; Nelder et al. 2018, Nieto et al. 2019; Kopsco et al. *in review* b). Institutions using these surveillance programs are now beginning to examine these data to assess behavior and epidemiologic factors related to tick encounters, for instance, where embedded ticks are found on the body, and the age of the bite victim (Xu et al. 2016). However, passive systems where ticks are mailed to research centers are lacking in rapid-feedback education of the public regarding specific tick

encounters. The TickSpotters program at the University of Rhode Island's TickEncounter Resource Center (TERC) is the first online, photo-based passive surveillance system in the country. It allows users to submit photographs of ticks along with information surrounding the encounter, including the user's identification of the tick. All submissions are reviewed and vetted by a tick expert, and a response email is sent within 24-hours identifying the tick to species, life stage, and estimated feeding duration with an overall accuracy of 96.7% (Kopsco et al. *in review* b); this is the time-critical information needed to trigger a decision about prescribing prophylactic treatment. In addition, tailored responses provide a detailed riskiness profile indicating low (less than one day to 1-day fed), moderate (1.5-2 days fed), or high risk (2.5 days or longer) of tick-specific disease transmission based on estimates of attachment duration and likely tick infection rate for the geographic region where the encounter occurred. Included public health messages provide best next actions for personal and pet protection and tick pathogen testing. Here, we present an analysis of five years of data from the TickSpotters surveillance system where we describe the tick encounters submitted and establish predictor variables for public tick identification ability. Because of the differential disease risk among tick species, it is important for the public to find ticks as quickly as possible and be able to properly identify the tick to species and stage. These skills can help avoid risk for tickborne disease infection (Wormser et al. 2006; Cook et al. 2015; Eisen et al. 2018). We sought to model these relationships to better identify potential educational targets for tick species identification.

Methods

Data collection

We used data collected from January 1, 2014 to December 31st, 2018 using Wufoo online forms program (SurveyMonkey, Inc.) to analyze and fit logistic regression models that 1) predicted a person's ability to correctly identify a tick, and 2) identified factors contributing to tickborne disease transmission riskiness of a tick bite based on its engorgement (less than 1 day fed = low risk; 1.5–2 = moderate risk; >2.5 = high risk) (Wormser et al. 2006). The online submission form provided TickSpotters users a tick identification chart and asked them to identify the encountered tick. Species options spanned ticks that are endemic to all regions of the United States and included those that are common human biters. Identification options for species were the most commonly encountered ticks including blacklegged or deer tick (I. *scapularis*), American dog tick (*Dermacentor variabilis* Say), Lone Star tick (*Amblyomma americanum* L.), Brown dog tick (*Rhipicephalus sanguineus* Latrielle), Pacific Coast tick (*Dermacentor occidentalis* Marx), western blacklegged tick (*Ixodes pacificus* Cooley and Kohls), Rocky Mountain wood tick (*Dermacentor andersonii* Stiles), Gulf Coast tick (*Amblyomma maculatum* Koch), and Cayenne tick (*Amblyomma cajennese* Fabricius). The user could also manually enter another species. The user was instructed to also identify the life stage (adult, nymph, or larva), enter the date the tick was found, on whom or what the tick found (on a person, pet, or loose), and state or province of residence. For both species and stage there was an "unknown" option if the user could not choose the tick or the life stage. A photograph of the tick was attached to the submission and TERC staff reviewed entries on a daily basis. Tick photographs were examined by TERC staff and identified to species, stage, and feeding duration, and an email was sent to the participant with the

correct identification and a risk assessment based on the tick/stage-specific diseases and prevalence of those diseases for the region of residence. Information was also provided in the email on how to prevent future tick bites and encounters on humans and pets by conducting regular tick checks, using permethrin repellent and tick knock-down pet products, and resources to submit ticks for testing should concern exist regarding infection.

Statistical Analysis

To model the probability of a correct tick identification by the public we fit a logistic regression, a generalized linear model (GLM) that connects a binary outcome to a predictor set using a logit link function (**Equation 1**). A logistic regression model was used as the deterministic function because of all of the variables analyzed were categorical, and the binomial distribution was used to model the probabilistic function because the correction variable for tick identification was binary (i.e. correction or no correction). Out of a set of eight covariates we investigated the possible predictive factors involved with a correct tick photograph identification. These covariates were: encounter season, tick species, tick life stage, engorgement or feeding status (days), uncertainty (binary measure) of researcher in the identification based on the photograph quality, state of encounter (fine spatial scale), region of encounter (broad spatial scale), and host (either loose and wandering, on a pet, or on a person).

Equation 1.

$$\boxed{log\left(\frac{p(X)}{1-p(X)}\right) = \beta_0 + \beta_1 X_1 \dots \beta_7 X_8}$$

Where, the log odds, or probability (**p**), that a tick is identified correctly (***X***), is equal to the coefficients ($\boxed{\beta_0 + \beta_1 \dots \beta_8}$) multiplied by the values of the eight covariates as mentioned above. ($\boxed{X_1 \dots X_8}$). The log odds increase or decrease according to a one-unit change in ***X.***

Training and testing data sets were established to build and test predictive models by dividing the entire data set (n=31,684) roughly in half (train n = 15,000; test n = 15,000) and automating random selection of those observations. Using the training set, the binomial logit equation was fit with each of the predictors and varied with correction to establish significance and strength of interaction. The relative quality of various combinations and potential interactions amongst all of the parameters were compared

using both Akaike's Information Criterion (AIC) and Bayesian Information Criterion (BIC). When there was disagreement between these two assessment methods, BIC was ultimately chosen due to the large sample size of the dataset and to avoid too complex a model that could result in false positive predictions. ANOVA table residuals were used to assess deviance of new models from the null model. Potential models were examined using McFadden's Pseudo R^2 for correlation, the Wald test for significance of predictors within a model, variable importance to compare parameters individually and amongst each other, and Hosmer and Lemeshow goodness of fit test for dichotomous risk assessment data. Finally, a receiver operator characteristic (ROC) curve was fit for each potential model to identify their sensitivity and accuracy on the test dataset. Computation and analysis were performed in R version 3.6.1/RStudio version 1.2.1335.

Results

From 2014-2018, TickSpotters received 31,684 submissions from every state in the U.S. and from several other countries including Canada and Mexico (**Table 1b**). Of these submissions, 78.4% of specimens could not be identified or were identified incorrectly to species and 65.91% were identified incorrectly to life stage (**Table 1b**). American dog ticks (*D. variabilis*) comprised the largest proportion of tick species submitted (32.03%), followed closely by blacklegged (deer) ticks (*I. scapularis*) (30.1%), then Lone Star ticks (*A. americanum*) (18.1%), and western blacklegged ticks (*I. pacificus*) (2.2%) (**Table 1a**). The majority of ticks submitted were adult stage (71.0%) females (70.8%), and entries were sent mostly from the Northeastern region of the country (43.9%), followed by the Southeast (23.0%), and Midwest (18.0%) (**Table 1b**). More than half of submissions (59.8%) came from states with high incidence for Lyme

disease (CT, DC, DE, MA, MD, ME, MN, NH, NJ, NY, PA, RI, VA, VT, WI, WV) (Bacon et al. 2008; Diuk-Wasser et al. 2012; CDC 2020) (**Table 1b**). Users sent reports in almost equal proportions during the spring (March-May; 39.1%) and summer (June-August; 36.2%) months (**Table 1b**). Humans were the most common host for the tick pictures submitted (71.7%), and of the ages we collected, just over 30% of submissions were reportedly on children (33.3%) (**Table 1b**). More than half of tick submissions (62.85%) were considered lower risk due to assessment of the scutal index as, at most, 1-day fed. However, the engorgement status of over one quarter of submissions (26.29%) was $\geq$ 2.5 days engorged, making those riskier tick encounters, if the ticks were infected (**Table 1b**). Overall, users incorrectly identified their specimen (either species or stage, or both) 83.7% of the time.

Table 1a. Summary of TickSpotters submissions (n=31,684) from 2014-2018 in order of proportions received.

Tick Species	n (%)	Tick Species	n (%)	Tick Species	n (%)	Tick Species	n (%)
American dog tick (*Dermacentor variabilis*)	10,150 (32.03%)	Brown dog tick (*Rhipicephalus sanguineus*)	664 (2.10%)	Bat tick (*Carios kelleyi*)	7 (0.022%)	*Hyalomma* spp.	2 (0.006%)
Blacklegged (deer) tick (*Ixodes scapularis*)	9,532 (30.08%)	Gulf Coast tick (*Amblyomma maculatum*)	336 (1.06%)	Cayenne tick (*Amblyomma cajennense*)	7 (0.022%)	Ornate sheep tick (*Dermacentor marginatus)*	1 (0.003%)
Lone Star tick (*Amblyomma americanum*)	5,746 (18.14%)	Pacific coast tick (*Dermacentor occidentalis*)	248 (0.783%)	Raccoon tick (*Ixodes texanus*)	5 (0.016%)	Cattle tick† (*Ixodes nipponensis*)	1 (0.003%)
Not a tick	1,914 (6.04%)	*Ixodes angustus*	33 (0.104%)	*Amblyomma* spp.	5 (0.016%)	Poultry tick (*Argas persicus*)	1 (0.003%)
Unidentifiable specimen	1,580 (4.99%)	Winter tick (*Dermacentor albipictus*)	22 (0.069%)	Spinose ear tick (*Otobius megnini*)	3 (0.009%)	*Ixodes* spp.	1 (0.003%)
Western blacklegged tick (*Ixodes pacificus*)	692 (2.18%)	Castor bean tick (*Ixodes ricinus*)	20 (0.063%)	East Asian longhorned tick (*Haemaphysalis longicornis*)	3 (0.009%)	Squirrel tick (*Ixodes marxi*)	1 (0.003%)
Rocky Mountain wood tick (*Dermacentor andersoni*)	675 (2.13%)	Woodchuck tick (*Ixodes cookei*)	10 (0.031%)	*Amblyomma mixtum*†	2 (0.006%)		

† Ticks received from overseas locations.

Table 1b. Summary of TickSpotters submissions (n=31,684) from 2014-2018 by evaluated predictor variables. Numbers represent the raw count of submissions in that category. Percentages of species, region, season, host, species ID correct, and life stage ID correct are out of the total number of submissions (n=31,684). Life stage was missing 17 observations, and therefore percentages are out of n=31,667. Percentages of bite risk are out of the total number of photo-confirmed ticks for which a feeding assessment could be made (n=29,508). Percentage of pet types is out of total pet submissions (n=5,627). Percentage of human age (n=14,277) is out of the total number of specimens reported on human hosts (n=22,705) minus the number of human cases for which age was not recorded (n=8,428) since this demographic was only documented since 2017. Percentage of stage Lyme status is out of the total number of U.S. submissions (n=29,528).

Life Stage		**n (%)**
	Adult	22,499 (71.04%)
	Female	15,924 (70.77%)
	Male	6,412 (29.22%)
	Nymph	5,141 (16.23%)
	Larva	512 (1.61%)
	Unknown life stage	3,515 (11.09%)
Region		**n (%)**
	Northeast	13,652 (43.09%)
	Southeast	7,296 (23.03%)
	Midwest	5,718 (18.04%)
	Pacific	2,302 (7.26%)
	Southwest	1,136 (3.58%)
	Canada	943 (2.97%)
	Mountain	570 (1.80%)
	Mexico	32 (0.101%)
	Noncontiguous US states	19 (0.060%)
	Non-North American countries	16 (0.050%)
Season		**n (%)**
	Spring	12,379 (39.07%)
	Summer	11,476 (36.22%)
	Fall	4,325 (13.65%)
	Winter	1,348 (4.25%)

Host		n (%)
	Human	22,705 (71.66%)
	Pet	5,627 (17.76%)
	Cat	223 (3.96%)
	Dog	2,543 (45.19%)
	Livestock	29 (0.052%)
	Other	21 (0.373%)
	Loose and wandering	3,352 (10.58%)
Bite Risk		**n (%)**
	Low (Less than 1 day to 1-day fed)	18,547 (62.85%)
	Moderate (1.5-2 days fed)	3,204 (10.86%)
	High (2.5 days or more fed)	7,757 (26.29%)
Human Age		**n (%)**
	Less than 1-year old to 9-years old	3,922 (27.47%)
	10 to 17-years old	831 (5.82%)
	18-years old and older	9,524 (66.71%)
State of Submission Lyme Incidence		**n (%)**
	High incidence	18,314 (59.75%)
	Low incidence	12,352 (40.24%)
Species ID Correct		**n (%)**
	Yes	6,843 (21.60)
	No	24,841 (78.40)
Life Stage ID Correct		**n (%)**
	Yes	10,801 (34.09%)
	No	20,883 (65.91%)

† Human age and pet type demographics began collection in 2017.
†† Endemic Lyme states include CT, DE, MA, MD, ME, MN, NH, NJ, NY, PA, RI, VA, VT, WI) (i.e., the 14 states reporting 95% of Lyme disease cases as of 2015) (Bacon et al. 2008; Diuk-Wasser et al. 2012; CDC 2019)

Of the four most commonly submitted tick species, western blacklegged ticks (*I. pacificus*) had the largest proportion of unidentified or misidentified submissions (87.7% incorrect), followed by Lone star ticks (*A. americanum*; 86.8% incorrect), American dog ticks (*D. variabilis*; 80.7%) and blacklegged ticks (*I. scapularis)* with 77.1% of submissions

incorrectly identified (**Fig. 1a**). Nearly 70% of users (69.7%) answered "I don't know" when asked to provide an identification for the top four tick species (**Fig. 2**). Almost 80% of people who submitted Lone star ticks (*A. americanum*) claimed that they could not identify the tick (77.6%), and large majorities of American dog ticks (71.3%), blacklegged ticks (63.7%) and western blacklegged ticks (63.6%) were also classified as "I don't know" when asked to provide a species identification from a chart (**Fig. 2**). However, when "I don't know" answers were removed, 77% of respondents correctly identified their tick to species, and 85% identified their tick correctly to stage (**Fig. 1b**). Small percentages of people misidentified both Lone star ticks (*A. americanum*) (n=24; 0.42%) and American dog ticks (*D. variabilis*) (n=88; 0.86%) as blacklegged ticks. Others mistook a blacklegged tick for other less dangerous species of tick such as American dog ticks (*D. variabilis*) (n=291; 3.5%); and Lone star ticks (*A. americanum*) (n=180; 1.88%).

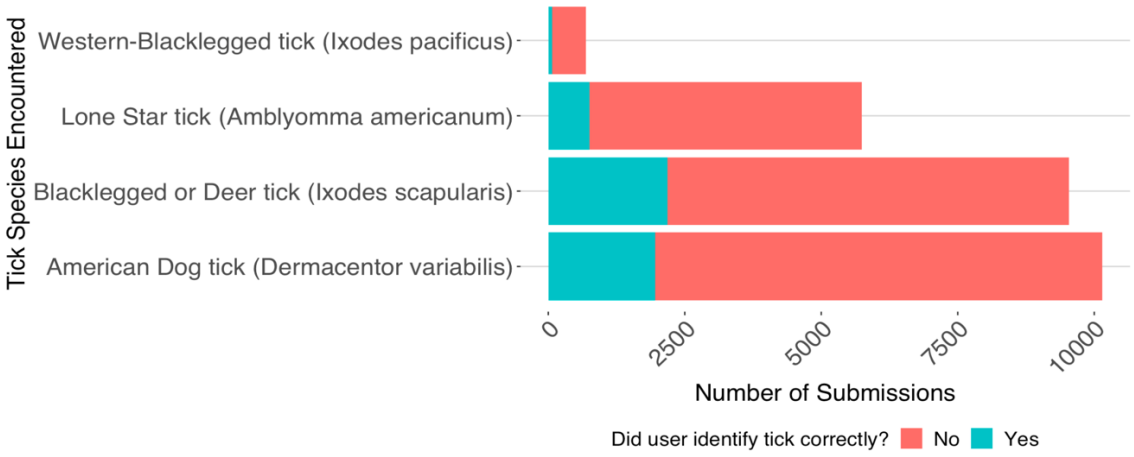

Figure 1a. The top four most commonly submitted tick species (82.4% of all submissions) to TickSpotters from 2014-2018 (n=26120) and proportion of users who identified correctly (both species and stage correct), or incorrectly (at least species or stage incorrect). "I don't know" responses were considered "incorrect."

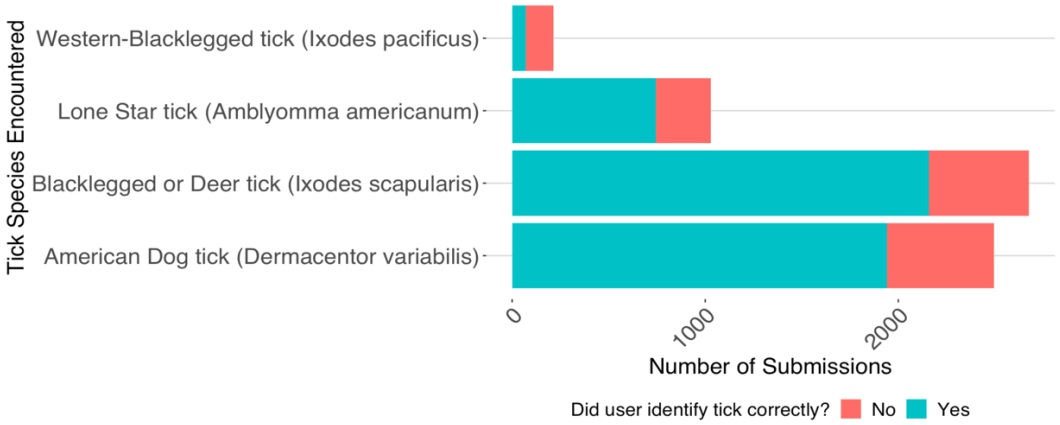

Figure 1b. The top four most commonly submitted tick species (82.4% of all submissions) to TickSpotters from 2014-2018 (n=6417) and proportion of users who identified correctly (both species and stage correct), or incorrectly (at least species or stage incorrect). "I don't know" responses were removed.

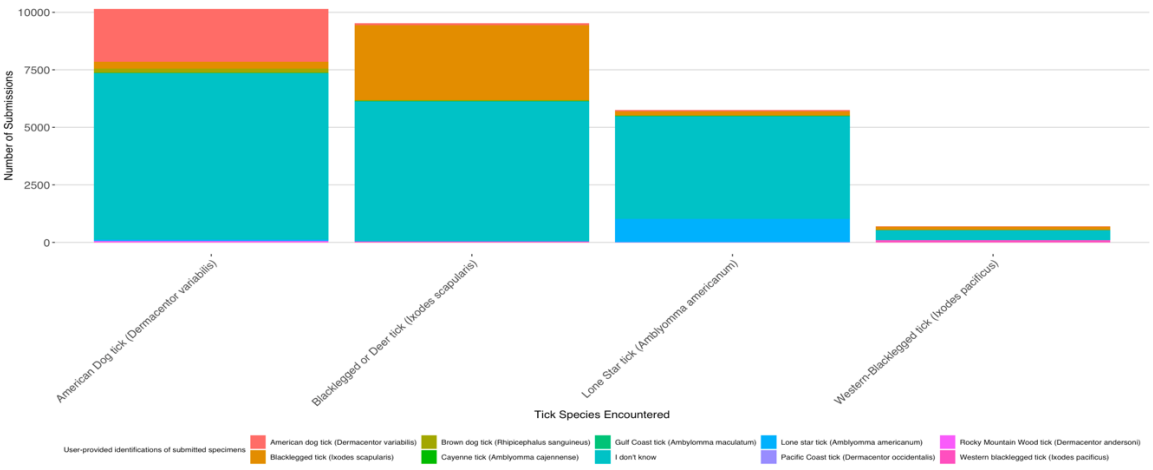

Figure 2. Identifications provided by TickSpotters participants from 2014-2018 for the top four most commonly submitted tick species.

After using the training dataset to establish models and evaluate them using the training dataset, the model incorporating tick life stage, host of the tick encounter, and bite risk as predictors of public tick identification accuracy was selected as optimal using BIC (**Table 2**). Neither state nor states grouped into regions were statistically significant or supported in AIC/BIC calculations to have an influence on a TickSpotters users' ability to

identify a tick correctly. A model including the region of submission as a random effect was also evaluated and found to have a high AIC value relative to the best fitting models. Adding interactions among the predictors within the GLM models also did not improve model fit. The Wald test revealed that the best fitting model (tick life stage + host of encounter + bite risk) also was the model to have all significant covariates. McFadden's pseudo R for this model was the smallest among models assessed (0.32; range = 0.32-0.46), with an R^2 value between 0.2 and 0.4 indicating excellent fit (Domencich and McFadden 1996). Within 20 iterations, there were no statistically significant values ($p < 0.05$) returned in Hosmer and Lemeshow goodness of fit (GOF) tests, indicating that there was no significant difference between the observed data and the values predicted by the model. The receiver operator curve for the optimal model reflected an area under the curve (AUC) of 0.647, which was similar to the other models assessed (**Fig. 5**). These results suggest that the three parameters included in the model demonstrate moderate predictive power for explaining the factors influencing public tick identifications.

The odds ratios for a correct tick identification, or the change in odds of the outcome compared to the reference category from the significant predictors, (**Table 3**) demonstrated that nymph stage ticks (OR: 0.40, 95% CI: 0.23, 0.68), and those that are engorged and in the "high risk" bite category (OR: 0.43, 95% CI: 0.29, 0.65) are less likely to be identified correctly by the public than adult stage ticks, and "low risk" bite category ticks. Ticks found on pets are more likely to be identified correctly by the public than ticks found on humans (OR:1.07, 95% CI: 1.01, 2.04).

Table 2. General linearized model summaries for the three top performing models predicting public tick identification ability. The model incorporating the covariates of tick life stage, host, and bite risk were the most predictive of public tick identification accuracy (bolded) and chosen as the optimal model due to it having the lowest Bayesian Information Criterion (BIC) score, while the Akaike Information Criterion (AIC) scores were within two points of each other (indicating non-significant differences). Coefficients are listed with the standard errors in parentheses below. Significant p-values are listed and coded according to the number of asterisks (see footnote).

	Stage+Host+Bite Risk	Stage+Host+Bite Risk+Region	Species+Stage+Host+Bite Risk
(Intercept)	**-1.28** ***	-1.17 ***	-16.09
	(0.10)	(0.13)	(1038.14)
Corrected_Stage_ID: Nymph	**-1.28** ***	-1.31 ***	-1.39 ***
	(0.29)	(0.29)	(0.30)
Corrected_Stage_ID: Larva	**-0.70**	-0.76	-0.87
	(0.62)	(0.63)	(0.64)
Host: On a pet	**0.70** ***	0.75 ***	0.78 ***
	(0.19)	(0.19)	(0.20)
Host: Loose and wandering	**0.35**	0.42	0.55
	(0.28)	(0.27)	(0.29)
Bite_risk: Moderate	**0.01**	-0.05	-0.29
	(0.25)	(0.25)	(0.25)
Bite_risk: High	**-0.90** ***	-0.93 ***	-1.17 ***
	(0.20)	(0.20)	(0.21)
Region: Southeast		-0.06	
		(0.19)	
Region: Midwest		-0.12	
		(0.19)	
Region: Mountain		-0.80	
		(0.78)	
Region: Southwest		-0.76	
		(0.42)	
Region: Pacific		-0.59	
		(0.32)	
Corrected_Species_ID: *Dermacentor variabilis*			14.64
			(1038.14)
Corrected_Species_ID: *Ixodes scapularis*			15.39
			(1038.14)
Corrected_Species_ID: *Rhipicephalus sanguineus*			13.98
			(1038.14)
Corrected_Species_ID: *Amblyomma maculatum*			-0.67
			(1195.33)
Corrected_Species_ID: *Amblyomma americanum*			14.82
			(1038.14)
Corrected_Species_ID: *Dermacentor occidentalis*			-0.38
			(1239.78)
Corrected_Species_ID: *Dermacentor andersoni*			14.56
			(1038.14)
Corrected_Species_ID: *Ixodes pacificus*			13.42
			(1038.14)
AIC	**1210.18**	1212.48	1180.59
BIC	**1246.52**	1274.76	1258.45
Log Likelihood	**-598.09**	-594.24	-575.30
Deviance	**1196.18**	1188.48	1150.59
Num. obs.	**1327**	1327	1327

*** p < 0.001, ** p < 0.01, * p < 0.05

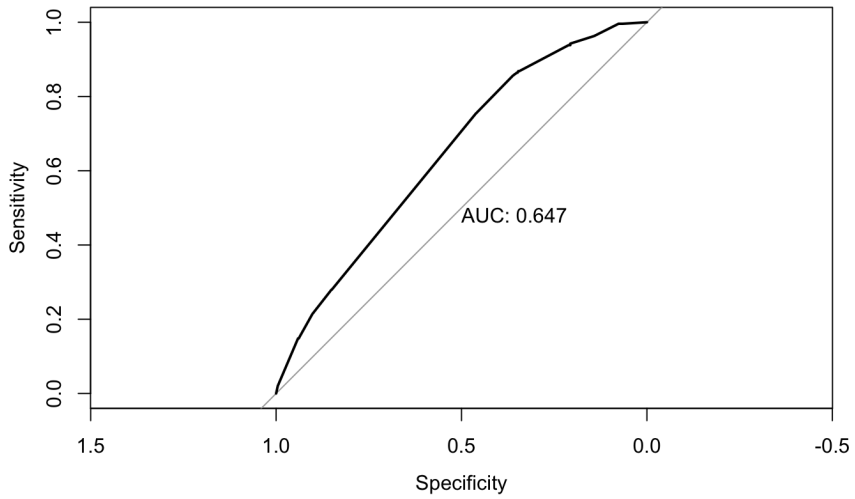

Fig. 5. Receiver operator curve (ROC) (sensitivity (true positives) versus 1- specificity (false positives)) for the optimal logistic regression binomial logit model predicting the effect tick life stage, host of tick encounter, and level of engorgement (bite risk) on tick literacy. Curve demonstrates that the model predicts the ability to identify a tick with low-moderate sensitivity. Area under the curve (AUC) = 0.647.

Table 3. Odds ratios and 95% confidence intervals for statistically significant predictors in the life stage + tick host + bite risk GLM model to predict factors involved in public tick identification.

Significant Predictors	Odds Ratio	2.5%	97.5%
Intercept (Reference) Life stage: Adult; Tick host: Human; Bite risk: Low	0.3204331	0.2667596	0.3849059
Life stage: Nymph	0.4060653	0.2397042	0.6878855
Tick host: Pet	1.5159550	1.05337047	2.1816822
Bite risk: High	0.4362756	0.29069655	0.6547597

Discussion

We used a novel photo-based tick surveillance and education program to establish a model that identifies and predicts factors that influence a user's ability to correctly identify a tick. This information presents a unique ability to better understand factors involved with tick encounters, and to adjust the focus of education efforts so that they better address knowledge gaps while empowering tickborne disease prevention behaviors. We found that over 80% of users reported not knowing or being certain of the type of tick that they had encountered, and that people who provided answers mistook both Lone star and American dog ticks for blacklegged ticks, and vice versa. Knowing the species of tick is critical for understanding the potential tickborne diseases that a bite victim is at risk of contracting. Blacklegged ticks (*I. scapularis)* can transmit numerous human pathogens in addition to the causative agent of Lyme disease (*Borrelia burgdorferi*) including *Babesia microti, Anaplasma phagocytophilum, Borrelia miyamotoi* (a relapsing fever spirochete), and Powassan/deer tick encephalitis viruses (CDC 2020). American dog ticks (Elchos et al. 2003) and Lone star ticks (Dalghren et al. 2016) can transmit their own suite of pathogens, including spotted fever group rickettsias, various ehrlichias, and *Francisella tularensis*, but generally not the agents transmitted by blacklegged ticks. Moreover, the tick infection rate in American dog ticks, lone star ticks, and western blacklegged ticks is generally much less than for *B. burgdorferi* in blacklegged ticks in their endemic regions. However, public fear surrounding Lyme disease has led to public myth that any tick can infect the bite victim with Lyme disease, and that an infectious dose of the pathogen can be transmitted instantaneously (Aronowitz 1991; Auwaerter et al. 2011), despite ample evidence that only *Ixodes*-species are capable of *B. burgdorferi* transmission (Stromdahl et al. 2018), and that there is a clear transmission delay (Cook 2015).

The optimal model for factors influencing a correct tick identification by a TickSpotters user predicts that users are unlikely to properly identify both adult and nymph-stage ticks, which puts them at a potentially increased risk for disease transmission as well as unnecessary fear. Across the United States and in Canada, nymphal ticks emerge during the spring and often go undetected due to their small size. Poppyseed-sized nymphal blacklegged ticks (*I. scapularis)* are the main transmitters of Lyme disease to humans, which corresponds to an increase in Lyme disease cases in the summer months after the up to 1-month incubation period (CDC 2020). Interestingly, residing in a blacklegged tick-endemic region (e.g. northeast or Midwest) does not positively influence a person's ability to identify these ticks correctly, providing further impetus for stronger education efforts. TickSpotters users were also less likely to identify ticks that had been feeding for 2.5 days or longer than those feeding within the low-risk category, pointing to not only heightened risk for disease transmission in this group, but that there is a need to provide guidance on key anatomical landmarks for tick identification when engorged. However, it is possible that the disproportionately large amount of submitted ticks that were found in the "low risk" category impacted the weight of this predictor in the model. Users were more likely to be able to identify a tick found on a pet than one found on a human or loose and wandering, suggesting that pet owners are more familiar with tick identification which could be a result of education from veterinarians, or simply because pet owners are at an increased risk for encountering ticks and have had more experience with ticks (Jones et al. 2018).

The TickSpotters emailed response is grounded in the theoretical health communication concepts such as the Health Belief Model (HBM), a well-established and effective predictor of prevention behaviors based on a person's perception of risk and benefits of behavior change, and perceived barriers to taking the recommended action (Rosenstock 1966, Jones et al. 2014). HBM-based programs recognize perceived benefit and absence of perceived barriers to action as the strongest predictors of adoption and adherence to health behaviors (Jones et al. 2014). Currently, we lack objective evidence for the efficacy of the TickSpotters response email in changing people's tick bite management and prevention behaviors although substantial anecdotal evidence through user feedback supports the hypothesis that obtaining an expert tick identification and riskiness assessment empowers both action and anxiety relief. Additional studies are needed to validate and improve on this tick literacy model for increasing tick-bite prevention behaviors (use of repellent, tick checks, tick habitat avoidance) and reducing the incidence of tickborne infection (Daltroy et al. 2007). One positive outcome of the modeling exercise in this study is recognition of the need for more specific guidance on key tick anatomical features to improve tick identification. For example, guides that help people focus on the adult tick scutum, which does not change and can still be visualized even as the tick engorges. We currently provide a pictorial tick identification guide on the submission page, but this series of tick photos does not contain a systematic method for what to focus on for making a correct identification.

There were several limitations to the study design and outcomes. It is reasonable to assume that users submitted ticks because they wanted our assistance, so would therefore demonstrate a greater lack of tick "literacy" than others who did not participate, so it may not be fair to extrapolate these results to the general public. However, this population clearly displays a high degree of need for educational

intervention. We counted “I don’t know” as an incorrect response in addition to if the respondent selected the wrong species and stage identification for their tick. A recent survey analysis modeling study found that a high rate of “I don’t know” responses suggests low confidence among the entire group, and not just those who said they were unsure of the answer (Graham 2020). In this study, nearly 70% of submissions selected “I don’t know”, and that choice was positioned in the middle of possible answers, suggesting that it was less subject to a survey construction bias. However, when “I don’t know” answers were removed, 77% of respondents correctly identified their tick to species, and 85% identified their tick correctly to stage. This suggests that those who did provide an identification were generally sure of their identification, though we did not assess a confidence level when asking if the user knew the type of tick they encountered, or whether they attempted to use the ID guide.

The optimal model also did not provide a high level of sensitivity (AUC of 0.647), possibly because we did not capture enough or the necessary information regarding tick encounters in our submission survey. In a meta-analysis conducted by Fischhoff et al. (2019) that examined literature from 1984-2018 that assessed factors involved with *I. scapularis* bites and the authors found that people from rural areas with 1) high densities of nymph-stage ticks, 2) who owned pets, and 3) actively landscaped their property had higher odds of experiencing tick bites. However, we do not know how these variables, or others, would affect tick identification ability. Despite these limitations, we successfully identified specific variables that can be included in theory-based education initiatives aimed at helping improve the public’s tick identification ability and potentially reduce incidence of tickborne disease.

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Manuscript 3

To be submitted to Zoonoses and Public Health

Tick biting trends on pets as revealed by crowdsourced data

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Abstract

Citizen science is increasingly utilized to track important vectors of companion animal disease, providing a scalable, cost-effective, and highly-sensitive strategy for identifying new foci, changing phenology, and associated disease impacts across wide geographies. We describe a digital tick surveillance program that provides photograph-based tick identification and public health messaging services free to the public, and share important insights into pet tick encounters and pressing tick bite prevention needs. From 2014-2018, the University of Rhode Island's TickSpotters program received 5,132 photograph submissions from U.S. states of ticks reported on pets, similarly distributed between high Lyme-incidence (54.4%) and low Lyme-incidence (45.6%) states. The blacklegged tick (*Ixodes scapularis* Say) vector of Lyme disease was the most common species found attached to pets (39.8%), followed by American dog ticks (*Dermacentor variabilis* Say) (28.2%), lone star ticks (*Amblyomma americanum* L.) (8.2%), brown dog ticks (*Rhipicephalus sanguineus* Latrielle) (5.9%), and western blacklegged ticks (*Ixodes pacificus* Cooley and Kohls) (4.5%). Pet attached ticks were almost entirely adults (89.5%), and ticks found on pets had a longer estimated engorgement time (median 2.5 days) compared to humans (median <1 day). *I. scapularis* had the highest median engorgement of the five top tick species found feeding on pets ($\chi^2 = 98.96$, $p < 0.001$). Ticks were spotted year-round; during spring and summer, ticks collected from pets represented 15.4% and 12.8% of all submissions, respectively, but increased to 28.5% and 35.2% during autumn and winter, respectively. Crowdsourced data reveal that mostly adult ticks are spotted on pets, and that they are detected later in the blood-feeding process than were ticks attached to humans, putting pets at heightened risk for tick-borne disease transmission. The doubling of reports of ticks found on pets during autumn and winter may reveal a critical knowledge

gap amongst the pet-owning general public regarding seasonal activity of *I. scapularis,* vector of Lyme disease, providing an opportunity for prevention-education to pet owners.

Introduction

Tick vectors can pose serious health risks to domestic companion animals, as well as their owners. Dogs, cats, and other pets are susceptible to numerous potentially deadly tickborne bacterial and protozoal diseases, such as Lyme disease, spotted fever rickettsioses, cytauxzoonosis, and tick paralysis toxicosis (Shaw et al. 2001; Kidd and Breitschwerdt 2003; Reichard et al. 2010; Chomel 2011; Nagamori 2015). Even in cases where animals are asymptomatic or display sub-clinical signs of tickborne disease infection, they can act as potential reservoirs for zoonotic pathogens (Mather et al. 1994; Shaw et al. 2001; Fritz et al. 2009; Shannon et al. 2017). People who own pets often spend more time in tick habitat, and because pets can easily transport ticks indoors, those living in households with pets are at higher risk of finding loose ticks as well as ticks attaching to others living in the home than those in households without pets (Jones et al. 2002; Jones et al. 2018). The strong association among pets, their owners, and zoonotic tickborne illness is evident in the literature, as dogs often act as sentinels for tickborne illness, particularly in cases of Rocky Mountain Spotted Fever (Elchos et al. 2003), and Lyme disease (Eng et al. 1988; Lindenmayer et al. 1991; Guerra et al. 2001; Johnson et al. 2004; Wagner et al. 2012).

Recent reports suggest that cases of human tickborne disease have more than doubled over the past decade (Rosenberg et al. 2018), no doubt also increasing significantly the tickborne disease prevention challenges faced by pet owners and veterinary professionals. Concurrently, distributions of tick species are changing, especially blacklegged (deer) ticks (*Ixodes scapularis*) and Lone star ticks (*Amblyomma americanum* L.) (Springer et al. 2014; Eisen et al. 2016; Dahlgren et al. 2016), exacerbating the problem while warming trends increase the length of time that ticks are active. Redistribution of wildlife, especially cervids such as white-tail deer, and movement of ticks on migrating

birds, is resulting in the incursion of ticks into more densely-populated suburban, peri-urban, and even urban areas (Shaw et al. 2001). As a result, new endemic foci (Abdullah et al. 2016; Hansford et al. 2018; Sonenshine 2018) are putting a larger demographic of humans and pets at risk for tick bites and illness. The factors contributing to more cases of tickborne diseases are complex and include broad ecological changes including changes in climate and land-use patterns (Hall et al. 2002; Guerra et al. 2002; Allan et al. 2003; Brownstein et al. 2005; Tran et al. 2013; Salkeld et al. 2015; Ostfeld and Brunner 2015; Gilliam et al. 2018), an increase in deer and other wildlife populations overlapping with human-inhabited space (Ginsberg et al. 1999; Rand et al. 2003; White and Gaff 2018), changes in human behavior resulting in enhanced exposure risks (Zeimes et al. 2014; Fischhoff et al. 2019), and overall improvements in disease diagnosis, surveillance, and reporting (Beard & Strickman 2014; Marques et al. 2015).

Passive surveillance, particularly involving the contributions of citizen science, has become an increasingly popular method for tracking ticks on pets and associated pathogens. Often, ticks are collected from pet owners at veterinary offices (Abdullah et al. 2016) or other research centers (Johnson et al. 2004; Xu et al. 2016; Nieto et al. 2018), identified to species, and tested for a wide range of pathogens. These electronic health records can then be examined over time to observe trends in tick distributions and infection rates (Sánchez-Vizcaíno et al. 2016; Tulloch et al. 2017). Ventures utilizing big data, such as internet search terms and social media, are also showing promise as a means of tracking tickborne disease in companion animals in an increasingly digital world (Guernier et al. 2016, Tulloch et al. 2019).

Photographs of encountered ticks have been shown to be another reliable method of rapid tick identification (Koffi et al. 2017; Kopsco et al. *in press*) that can be used to not only track tick trends, but also relay important information about potential disease risk to

pet owners or veterinarians. The TickSpotters program at the University of Rhode Island's TickEncounter Resource Center (TERC) is an online, photo-based passive surveillance system, staffed by tick experts, with an overall accuracy of 96.7% (Kopsco et al. *in review*). The system allows users to submit photographs of ticks along with information surrounding each encounter; the simple submission process includes guided self-identification of the tick which provides an opportunity to assess public capacity for tick identification. Moreover, a response email is sent within 24-hours that confirms the identity of the tick to species and stage, estimates the duration of attachment, and provides tailored guidance regarding likely riskiness for infection and best next actions to prevent disease and avoid future tick bites. The likely duration of feeding is estimated by comparing the submitted tick to a visual tick growth tool available on the TERC website; feeding duration estimates are based on the scutal index (Yeh et al. 1995; Falco et al. 2018).

The purpose of this study was to examine tick bite trends on pets as revealed by TickSpotters photograph-based tick surveillance to identify potential areas for improvements in tick bite prevention education and risk intervention. We hypothesized that submissions from pets would exhibit unique trends that differed from submissions of ticks found on humans or those found unattached in the home. Specifically, we expected that pets would experience more encounters with ticks than humans during the fall and winter seasons when owners potentially assume that ticks are no longer an active concern, and that ticks found attached to pets would have a longer duration of attachment than ticks found on humans.

Methods

Data collection

We performed a retrospective analysis on data collected through the TickSpotters photograph-based crowdsourced surveillance program using Wufoo online forms software (SurveyMonkey, Inc.) from January 1, 2014 to December 31st, 2018 to describe a population of domestic animal tick encounters as reported by their owners or veterinarians. Prior to uploading a photograph of the specimen to the system, instructions were provided for how to take a photograph of the specimen with a size reference, proper lighting, and clear focus to ensure the image highlighted the necessary anatomy to facilitate correct identification by researchers. Submissions with pictures that could not be identified by TERC researchers were recorded as "Unknown," and a request was sent for an additional improved photograph. Records were accordingly updated with an identification if a better picture was sent in response to this request. The online submission form also provided TickSpotters users with a tick identification chart and submitters were asked to identify the encountered tick as a means for gauging public tick identification ability. Species options included commonly encountered ticks of human and domestic animal concern endemic throughout the United States; these included blacklegged or deer tick (*Ixodes scapularis* Say), American dog tick (*Dermacentor variabilis* Say), lone star tick (*Amblyomma americanum* L.), brown dog tick (*Rhipicephalus sanguineus* Latrielle), Pacific Coast tick (*Dermacentor occidentalis* Marx), western blacklegged tick (*Ixodes pacificus* Cooley and Kohls), Rocky Mountain wood tick (*Dermacentor andersonii* Stiles), Gulf Coast tick (*Amblyomma maculatum* Koch), and cayenne tick (*Amblyomma cajennese* Fabricius). Tick species not on this list could be entered manually into the form if known or suspected. Submitters were instructed to identify the life stage (adult, nymph, or larva), enter the date the tick was

found, on whom or what the tick was found (on a person, pet, or loose), and the most likely zip code where the tick encounter occurred. An “I don’t know” option was provided for both species and life stage. TERC staff reviewed entries daily, and tick photographs were identified to species, stage, and feeding duration. A tailored email response was sent to the participant with species identification confirmation and a riskiness assessment based on the tick/stage-specific diseases and tick infection estimates of those diseases derived from published studies if available for the region where the tick was encountered. Information was also provided in the email on how to prevent future tick encounters and bites by conducting regular tick checks, using permethrin repellent and tick knock-down pet products, and resources to submit ticks for testing should concern exist regarding infection.

Statistics

We calculated basic descriptive statistics and proportions to understand the relative contributions of different tick species and feeding times to the overall submission of ticks from pets. To determine whether there were significant differences in duration of attachment (based on an engorgement index) among tick species, we compared estimated days of attachment using a Kruskal-Wallis one-way analysis of variance due to unequal variances and non-normal distribution of the tick feeding times (Shapiro-Wilk Normality Test for Engorgement (Days): p-value = < 0.001, and Bartlett's test for homogeneity of variances for factor Species: p-value = < 0.001). Post-hoc pairwise analysis using the Dwass-Steel-Crichtlow-Fligner method and adjusted p-values was subsequently conducted to identify differences between species. We also performed a Pearson’s chi-square analysis of variance on the number of tick submissions by host type submitted for each season (spring, summer, fall, winter). Effect sizes to understand the magnitude of

the significant differences for both of these analyses were calculated (epsilon-squared and Cramer's V, respectively) and listed along with significant p-values and confidence intervals (Rea and Parker 1992).

Results

From January 1, 2014 to December 31st, 2018 TickSpotters received 31,684 photo submissions from throughout the United States and several other countries. Of those reported from the U.S. (n = 29,528), 17.3% (n=5,132) of submissions were specimens removed from pets, while 72.4% (n=21,366) were reportedly found on human hosts, and 10.3% (n=3,030) were found unattached to a host (i.e. loose and wandering). Over 70% of the specimens reported on pets were sent from Northeastern (Maine, New Hampshire, Vermont, Massachusetts, Rhode Island), Mid-Atlantic (Connecticut, Delaware, District of Columbia, Maryland, New York, New Jersey, Pennsylvania, Virginia) and midwestern (Illinois, Indiana, Iowa, Kansas, Michigan, Minnesota, Missouri, Nebraska, North Dakota, Ohio, South Dakota, Wisconsin) states, with less than 20% of submissions coming from each of the other regions of the country (**Table 1**). Roughly half (53.5%) of submissions came from states with high incidence of human Lyme disease (CT, DC, DE, MA, MD, ME, MN, NH, NJ, NY, PA, RI, VA, VT, WI, WV) (Bacon et al. 2008; Diuk-Wasser et al. 2012; CDC 2020) (**Table 1**). Reports were of specimens largely found on pet dogs (45.7%), however nearly half of submissions did not report a specific pet type as this information was not collected by the submission form until the end of 2017. Seventy-three percent (n=3,744) of specimens were incorrectly identified to species, and 53% (n = 2,699) had an incorrect life stage identified (**Table 1**). Over seventy percent (72.9%) of respondents responded "I don't know" when entering the tick species, and 45.2% (n = 2,321) did not know what life stage they encountered; "I don't know" responses were categorized as

incorrectly identified. However, when "I don't know" responses were removed from the overall respondent-provided species and life stage identification correction counts, 74.5% of respondents correctly identified the tick species submitted, and 89% of respondents correctly identified the life stage.

Table 1. Distribution of confirmed TickSpotters submissions from pets, 2014-2018 (n=5,132). Engorgement estimates were determined by comparison to a tick engorgement gauge based on the scutal index (Yeh et al. 1995). High-Lyme incidence states include CT, DC, DE, MA, MD, ME, MN, NH, NJ, NY, PA, RI, VA, VT, WI, WV (Bacon et al. 2008; Diuk-Wasser et al. 2012; CDC 2020). Proportions and totals for tick engorgement are based on the total number of ticks submitted (i.e. minus the "Not ticks" and unknown tick species for which a duration of attachment could not be made).

Species	**n = 5132 (%)**
Blacklegged or Deer tick (*Ixodes scapularis*)	2044 (39.8)
American Dog tick (*Dermacentor variabilis*)	1625 (31.6)
Lone Star tick (*Amblyomma americanum*)	400 (7.8)
Brown Dog tick *(Rhipicephalus sanguineus*)	263 (5.1)
Western-Blacklegged tick (*Ixodes pacificus*)	230 (4.5)
Unknown	207 (4.0)
Rocky Mountain Wood tick (*Dermacentor andersoni*)	148 (2.9)
Gulf Coast tick (*Amblyomma maculatum*)	65 (1.3)
Not a tick	59 (1.1)
Pacific Coast tick (*Dermacentor occidentalis*)	53 (1.0)
Ixodes angustus	15 (0.3)
Rabbit tick (*Haemaphysalis leporispalustris*)	7 (0.1)
Winter tick (*Dermacentor albipictus*)	4 (0.07)
Soft tick (*Argasidae* sp.)	3 (0.06)
East Asian Longhorned tick (*Haemaphysalis longicornis*)	2 (0.04)
Spinose ear tick (*Otobious megnini*)	2 (0.04)
Woodchuck tick (*Ixodes cookei*)	2 (0.04)
Raccoon tick (*Ixodes texanus)*	1 (0.02)
Amblyomma spp.	1 (0.02)
Poultry tick (*Argas persicus*)	1 (0.02)
Life Stage	**n = 5132 (%)**
Adult	4594(89.5)
Nymph	207 (4.03)
Larva	52 (1.01)
Unknown	279 (5.43)
Tick Engorgement	**n = 5033 (%)**
Less than one day	1781 (35.4)
1-2 days	698 (13.9)
2.5-3.5 days	1065 (21.2)
4-5 days	1194 (23.7)
5.5-7.5	276 (5.5)
> 7.5 days	19 (0.38)
Region	**n = 5132 (%)**
Northeast (CT, ME, MA, NH, RI, VT)	945 (18.4)
Mid-Atlantic (DE, DC, MD, NJ, NY, PA, VA)	1582 (30.8)
Midwest (IL, IN, IA, KS, MI, MN, MO, NE, ND, OH, OK, SD, WI)	1149 (22.3)
Southeast (AL, AR, FL, GA, KY, LA, MS, NC, SC, TN, WV)	753 (14.7)
Pacific (CA, OR, WA)	662 (12.9)
Southwest (AZ, NM, TX)	285 (5.5)
Mountain (CO, ID, MT, NV, UT, WY)	140 (2.7)

Noncontiguous (AK, HI, PR)	8 (0.2)
Lyme Incidence	**n = 5132 (%)**
High incidence states	2788 (54.4)
Low incidence states	2344 (45.6)
Pet type	**n = 5132 (%)**
Dog	2345 (45.7)
Cat	204 (4.0)
Livestock (horse, cattle, etc.)	24 (0.5)
Other (wildlife, game, etc.)	18 (0.3)
Unknown pet (pet type only collected beginning in 2017)	2541 (49.5)
Correct Identification by User ("I don't know" included)	**n = 5132 (%)**
Species identified correctly	1388 (27.0)
Life stage identified correctly	2433 (47.4)
Correct	
Species identified correctly	1181 (74.5)
Life stage identified correctly	1412 (89.1)

The four most commonly encountered tick species by pets were blacklegged ticks (*I. scapularis*) (40.5%), followed by American dog ticks (*D. variabilis*) (28.2%), Lone star ticks (*A. americanum*) (8.2%), and brown dog ticks (*R. sanguineus*) (6.5%). Adult stage ticks comprised 90.8% of the submitted tick photographs for pets, and while the largest percentage of tick photos submitted showed ticks that had been attached to pets for less than one day, more than 50% of ticks were attached for at least 2.5 days (**Table 1**). The median engorgement of ticks fed on pets was 2.5 days (standard deviation = 2.11, range 1-9 days), while the median engorgement of ticks reported from humans was 1 day (standard deviation = 1.39, range 1-8 days), and those found unattached (either unfed or fed to repletion and detached) also fed for a median of 1 day (standard deviation = 2.29, range = 1-9 days) (**Fig. 1**). There was a significant difference in duration of tick attachment depending on host type (person, pet, unattached) ($\chi^2 = 4486.2$, $p < 0.001$), and a large effect size (Cramer's $V = 0.28$, CI [0.27,0.29] (**Fig. 1**) (Rea and Parker 1992). All feeding duration time categories displayed significantly different ($p<0.001$ or $p<0.01$) proportions of hosts with ticks of that engorgement. We received one tick submission that was estimated to be attached for 5.5 days on a human, and only two estimated to be attached at approximately

9 days each (one on a pet and one was found on the floor after detaching from an unknown host) (**Fig. 1**).

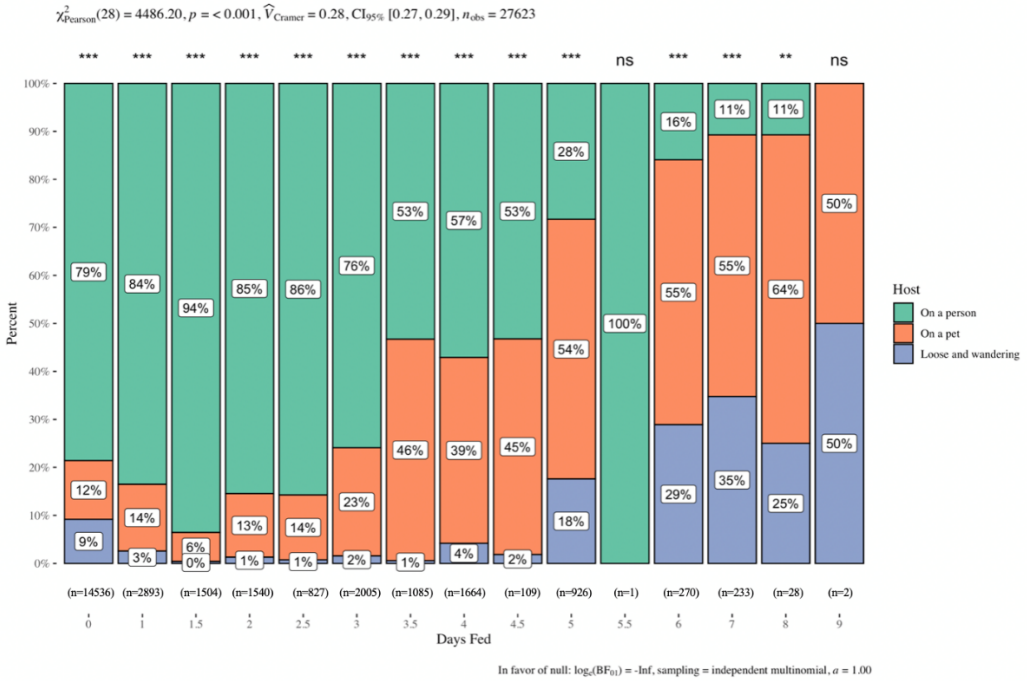

Fig. 1. Comparison of estimated tick feeding time (days) on pets versus those found on humans or found unattached for ticks reported to the TickSpotters Program from 2014-2018. Tick feeding time was assessed by comparison to a pictorial tick engorgement chart based on the scutal index (Yeh et al. 1995). Median engorgement for human-encountered ticks (n=20,710) was 1 day-fed (SD = 1.39, SE = 0.01, range = 0-8 days). Median attachment for pet-encountered ticks (n=5,033) was 2.5-days-fed (SD = 2.11, SE = 0.01, range = 0-9 days). Median engorgement for unattached ticks (unfed or replete) (n=1880) was 0 days-fed (SD = 2.29, SE = 0.05, range = 0-9 days). *** = p<0.001. ** p<0.01. ns = Not significant.

Of the five most commonly submitted tick species, blacklegged ticks (both *I. scapularis* and *I. pacificus*) displayed the highest median attachment duration at the time they were detected on pets based on their engorgement index (3 days), followed by brown dog ticks (2.5 days), Lone star ticks (2 days), and American dog ticks (< 1 day). There was a highly significant difference among these five species (χ^2=546.91, p <0.001) in their attachment duration, but the effect size, or practical magnitude of this difference was only moderate (ε^2=0.12, CI [0.10-0.14]) (**Fig. 2**) (Rea and Parker 1992). Post-hoc pairwise comparisons showed highly significant (p<0.001) differences between attachment durations at detection for each of these tick species when feeding on pets (**Fig. 2**).

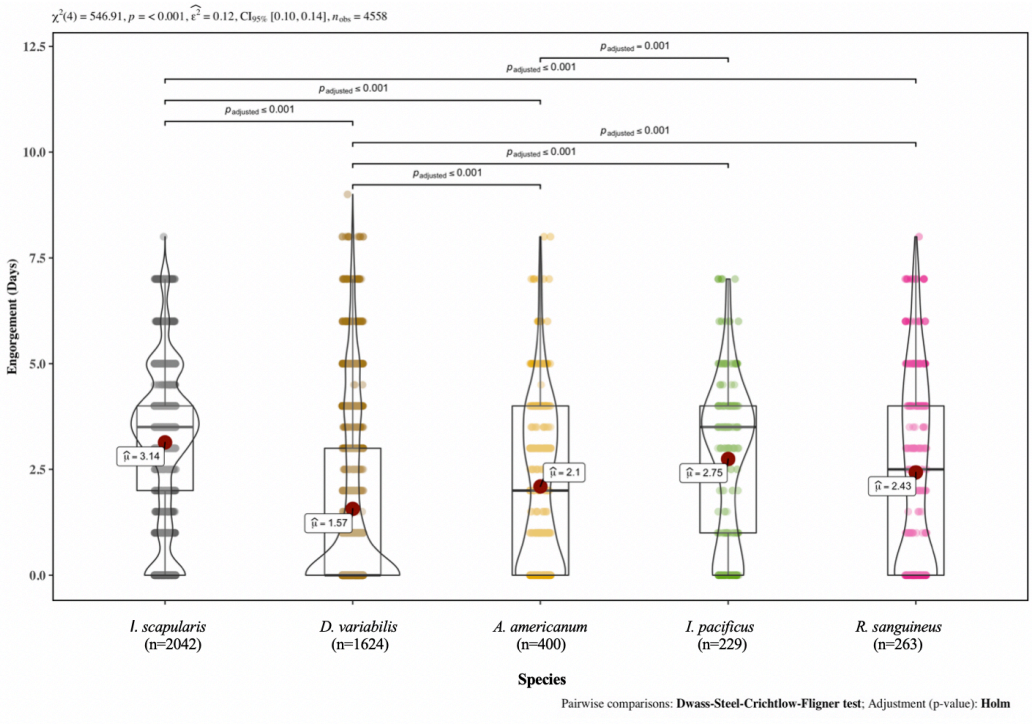

Fig. 2. Violin boxplot displaying engorgement at detection (days) of the five most commonly reported tick species found on pets that were submitted to TickSpotters from 2014-2018. Feeding times were estimated by comparison to a pictorial tick engorgement chart based on the scutal index (Yeh et al. 1995). The horizontal bar within the box represents the median engorgement for each species. The dots represent the mean engorgement. Kruskal-Wallis nonparametric analysis of variance tested statistical difference among the species engorgement distributions. Effect size is denoted by episilon^2. Post-hoc pairwise comparisons were conducted using the Dwass-Steel-Crichtlow-Fligner method and (Holm) adjusted p-values for statistically significant distributions are noted between species whose overall submissions were statistically different in engorgement.

The proportion of tick submissions from pets was significantly different from those on humans and from unattached ticks in each season ($p<0.001$) as well as across seasons ($p<0.001$ (**Fig. 3**). In the spring (March-May) and summer (June-August), ticks reported on pets constituted only 16% and 12% of all submissions, but rose to 29% of all submissions in the fall (September-November) and 34% of all submissions in the winter months (December-February) (**Fig. 3**). The proportion of submissions reporting unattached specimens remained relatively constant across months (between 9% and 12% of all submissions) (**Fig. 3**).

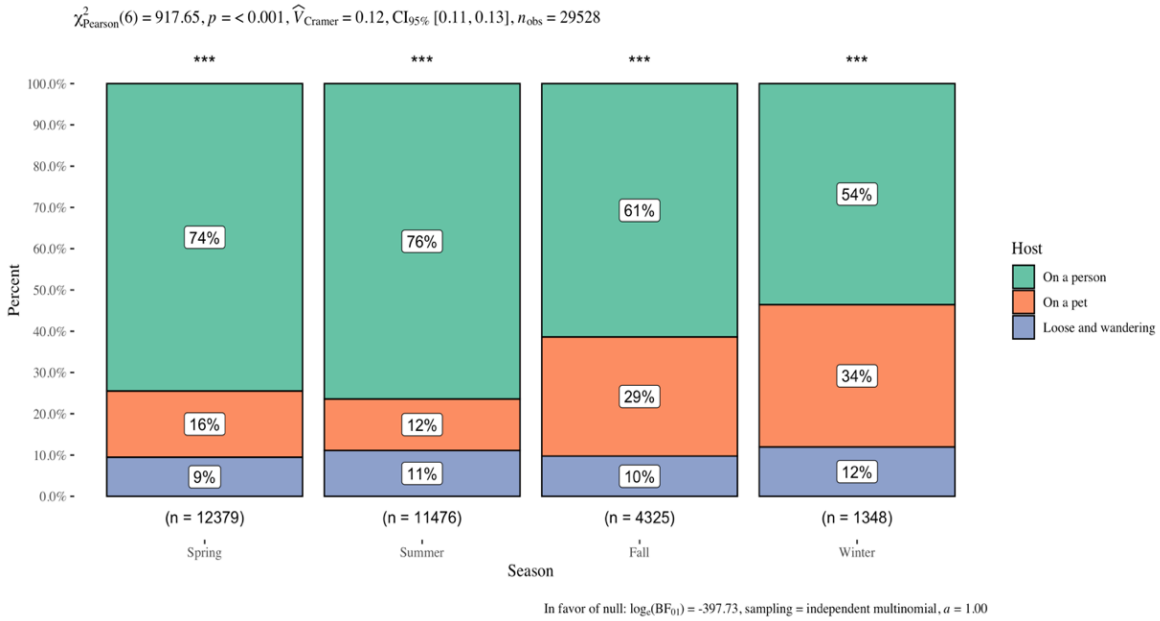

Fig. 3. Comparison of seasonal tick encounter submissions by host (i.e. on whom or how the tick was found) out of the total United States submissions (no pet tick encounters were submitted from other countries) using Pearson's chi-square analysis. Effect size is denoted by Cramer's *V*. *** = $p < 0.001$.

Discussion

We described 5,132 domestic companion animal tick encounters as reported to a photograph-based passive tick surveillance system. Overall, we found that this group of pets encounter commonly occurring tick species that present not only a potential disease risk to them, but also a zoonotic disease risk for the humans with whom they share a household (Jones et al. 2018). Blacklegged (deer) ticks (*I. scapularis*) were the most commonly reported species encountered by pets, as well as the species demonstrating the highest median feeding duration rate of the five most commonly encountered tick species. It is well documented that risk for transmission of tickborne pathogens increases with longer duration of tick feeding (Piesman et al. 1987; Sood et al. 1997; Kidd and Breitschwerdt 2003; Dolan et al. 2017; Eisen 2018). Taken together, these two observations are troubling due to the numerous diseases that *I. scapularis* can vector and transmit to both pets and humans. Adult *I. scapularis* are most active in the fall months, and we found that adult blacklegged ticks were the most commonly reported tick on pets. The proportion of ticks reported from pets more than doubled in the fall and winter months **(Fig. 3**) indicating that there remains a general lack of awareness that colder months still pose a risk for tick bites. Opportunities exist to increase awareness on this point among pet owners through education by both veterinarians and public health agencies promoting a One Health focus to tickborne disease prevention. We propose below several targeted areas for educational intervention that can potentially address our findings and help protect pet and human health.

It is imperative that the public have knowledge of seasonal tick activity in their locale (Dryden et al. 2004). Misconceptions regarding which ticks are capable of transmitting which diseases is pervasive (Halperin et al. 2013) and can lead to both undiagnosed disease cases, as well as falsely believing that one is infected. In particular, Lyme disease is often surrounded in controversy and confusion (Auwaerter et al. 2011).

Awareness that *I. scapularis* and *I. pacificus* ticks potentially carrying the Lyme disease agent are principally active in the fall and winter would help support year-round tick prevention in areas where these ticks occur (Dryden et al. 2004). Our findings emphasize the importance of publicizing these ticks' seasonal activity, with information disseminated through various channels and means at veterinary clinics, as well as through public health social media pages before the fall tick season begins, as well as during those seasons.

Tick checks on pets are important for detecting and removing loose and wandering ticks before attachment, and early on in the feeding process due to transmission delays for pathogens (Piesman et al. 1987; Sood et al. 1997; Kidd and Breitschwerdt 2003; Dolan et al. 2017; Eisen 2018). Pet checks should be conducted routinely, both immediately after outdoor activity as well as during regular intervals after the pet has come inside, to catch any ticks that may have been missed in previous checks. Common areas for tick attachment are around the head and ears, armpits, belly, paws, and tail (Wright et al. 2018), and these ticks should be removed as soon as they are found using pointed tweezers (Jones et al. 2002). While it may be that the higher proportion of "found" ticks on pets than humans during fall and winter is related to fewer ticks successfully attaching to humans due to more clothing barriers, the longer duration of tick attachment on pets compared to humans is suggestive that pets are not being checked regularly or thoroughly enough, or that owners are less inclined to continue use of effective tick bite prevention products when they believe tick activity is lower.

Effective industry-tested products, including topical tick bite prevention and vaccines are a necessary part of the tickborne disease prevention toolkit in pets (Littman et al. 2006; de la Fuente et al. 2015). Numerous topical products exist but often do not repel or kill all species of ticks, and many require a tick to bite in order to get a lethal dose of the pesticide. We first recommend products that repel and kill or immobilize ticks but suggest

that veterinarians and public health professionals discuss with pet owners their concerns regarding pesticide usages and derive a solution that will both placate any fears regarding synthetic chemical usage and still keep pets protected (Peterson 2000).

Pet owners need to be aware that traveling with pets to areas with different tick species can potentially result in tick importation. Passive tick surveillance in the United Kingdom (U.K.) revealed that over the past ten years, canine travel resulted in the introduction of ten new tick species from 15 different countries, including the importation of *R. sanguineus* from Cyprus and Spain (Abdullah et al. 2016; Hansford et al. 2018). TickSpotters surveillance has also revealed "hotspots" of high *R. sanguineus* activity in the southwestern and southeastern U.S., and it is important that pet owners and veterinarians be made aware of these areas so that pets can be properly protected when traveling in order to avoid transporting ticks home. Pets are likely responsible for transporting the newly invasive Asian longhorned tick (*Haemaphysalis longicornus*) into new foci. One confirmed TickSpotter report demonstrated pet transport of an adult female *H. longicornus* from an endemic foci in New Jersey to Colorado. Movement of even a single engorged female on a pet could found a new population of *H. longicornus* as this tick is capable of reproducing parthenogenically.

Photograph-based tick surveillance is an effective means for broadly monitoring tick trends on domestic companion animals, even on a national scale. Additionally, TickSpotters was able to deduce important gaps in pet owner behavior and practices related to tick prevention as well as inform and encourage users of the platform about best tick prevention practices through timely tailored emailed responses. There were a few limitations to this method that could be improved with minor changes to the intake survey. Many of the 3,030 ticks classified as loose and wandering were fully engorged ticks that could have fallen off of a pet. However, in those cases, we did not know for certain whether

there was a pet was in the household but we provided pet-tailored prevention information in those cases regardless. We also recognize that sampling bias could affect these results because submissions were self-directed, and the knowledge and behaviors of this sample may not be reflective of a larger population. Ultimately, however, our investigation identified several important opportunities for prevention-education to pet owners.

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Manuscript 4

To be submitted to Ticks and Tick-borne Diseases

Examining the Spatial Distribution of Photograph-based Passive Tick Surveillance

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Abstract

Burgeoning cases of tickborne disease present a significant emerging health problem in the United States. Passive tick surveillance is gaining traction as an effective way to understand disease risk factors and collect epidemiologic data, however validation is required to gauge limitations such as barriers and motivations for public reporting, as well as whether reports reflect accurate tick abundance and range. In particular, photograph-based tick surveillance can be an accurate alternative to in-hand tick specimen identification when used to collect tick distribution data and related encounter demographics. We compared the Federal Information Processing Standard (FIPS) code and county location of TickSpotters reports from 2014-2019 to nationwide published county reports for three species of medical concern: *Ixodes scapularis* Say, *Ixodes pacificus* Cooley and Kohls, and *Amblyomma americanum* Linneaus. We tallied the number of TickSpotters reports for each tick species according to the criteria designating a county as having "established" or "reported" populations of each tick, and found that TickSpotters captured at least half of the reported counties of documented occurrence, and potentially identified hundreds of new counties of establishment and reported for these species. We detected the largest potential increase of *I. scapularis* expansion in Michigan and Texas; Washington state had the largest increase of newly detected *I. pacificus* county presence. The largest expansion in reports of *A. americanum* were in Kentucky, Illinois, and Virginia. These findings demonstrate the validity of a photograph-based tick surveillance system to detect tick distributions on a nationwide scale, potentially identify new foci of occurrence, and highlight at-risk localities that

may benefit from additional tick bite prevention education to increase awareness of ticks residing in those areas.

Introduction

Of the nearly 650,000 cases of vector-borne disease reported in the United States between 2004 and 2016, greater than 75 percent were tickborne and this proportion represents a two-fold increase in tickborne illnesses during that time period (Rosenberg et al. 2018). Current estimates suggest that there are approximately 300,000 new cases of Lyme disease each year, and although 95% of cases are reported from only 14 states, it is still the most common vector-borne disease in the United States (CDC 2018). Health economists estimate that the current cost to the U.S. healthcare system of Lyme disease alone is between $712 million and $1.3 billion annually (Adrion et al. 2015), while reports of other tickborne illnesses like babesiosis, ehrlichiosis, Rocky Mountain Spotted Fever, and several fatal encephalitic viruses have doubled and tripled as their tick vector ranges expand across the country (CDC 2018; Springer et al. 2015; Eisen et al. 2016; Dahlgren et al. 2016; Xu et al. 2019). Aside from direct health care costs, the surge in these illnesses also presents indirect impacts such as a rise in babesia-infected blood bank reserves that have resulted in ~30% fatality rates among transfusion patients who received contaminated blood products (Lobo et al. 2013). There are numerous complex factors contributing to this recent increase in tickborne diseases including ecological alterations resulting from changes in climate and land-use patterns (Hall et al. 2002; Guerra et al. 2002; Allan et al. 2003; Brownstein et al. 2005; Tran et al. 2013; Salkeld et al. 2015; Ostfeld and Brunner 2015; Gilliam et al. 2018), an overlap of deer and other wildlife populations with human-inhabited space (Ginsberg et al. 1999; Rand et al. 2003; White et al. 2018), changes in human behavior that have resulted in enhanced exposure risks (Zeimes et al. 2014; Fischhoff et al. 2019), and overall

improvements in disease diagnosis, surveillance, and reporting (Beard & Strickman 2014; Marques et al. 2015). Monitoring tick and tickborne pathogen ecology requires a multipronged approach.

Passive surveillance, including in-hand specimens or digital images sent to research facilities, is a validated and widely-employed tool to estimate and observe changes in tick abundances, disease prevalence, and habitat range (Johnson et al. 2004; Rand et al. 2007; Xu et al. 2016; Koffi et al. 2017; Ripoche et al. 2018; Nieto et al. 2019; Xu et al. 2019; Kopsco et al. *in review*). Due to the high financial cost and time burdens associated with active tick surveillance efforts, institutions are now employing passive surveillance programs to both track tick trends, and also to assess behavior and epidemiologic factors related to tick encounters (e.g. bite location and age of bite victim) (Xu et al. 2016; Nieto et al. 2019). In addition to identifying where tick species are active, passive surveillance techniques can be used as a reliable and timely method of detecting human tickborne disease risk, particularly in emerging regions (Rand et al. 2007; Ripoche et al. 2018; Gasmi et al. 2019), as well as tracking newly emerging pathogens in established tick vectors (Xu et al. 2018). However, because passive systems where ticks are mailed to research centers for identification are often slow and lacking in rapid-feedback education of the public regarding tick encounters, digital photograph and email-based programs may prove more useful for both surveillance data and tick bite prevention education (Koffi et al. 2017; Kopsco et al. *in review*). In order to control for the subjective nature of this type of surveillance it is critical to establish the motivations behind why participants submit reports, and whether reports are reflective of tick abundance and geographic distribution.

The TickSpotters program at the University of Rhode Island's TickEncounter Resource Center (TERC) is a crowdsourced photograph-based passive surveillance system and prevention education tool. It provides the opportunity for the public to submit photographs of ticks with information surrounding the encounter, including the user's presumed identification of the tick. A response email is sent within 24-hours that confirms the identity of the tick to species and life stage, as well as estimates attachment time based on comparison to a tick growth comparison chart and related to the scutal index (Yeh et al. 2005); this feedback to users provides time-critical information that can help clarify disease risks as well as inform decisions about taking disease preventive action. Based on the duration of attachment, a risk profile that suggests low, moderate, or high risk of tick-specific disease transmission is included with resources on tick testing labs. Tailored public health messages for preventing future tick encounters are also provided, including instructions on how to perform a proper tick check, which tick repellent products are effective to use on people and pets, and in which specific habitats ticks can be found (e.g. trail edges). The estimated zip code of the tick encounter is also recorded.

We used photograph-based tick surveillance data collected by the TickSpotters program from January 1st, 2014 to December 3rd, 2019 and compared them to datasets of county distribution for *I. scapularis*, *I. pacificus*, (Eisen et al. 2017), and *A. americanum* (Springer et al. 2014). We hypothesized that TickSpotters reports are capable of identifying a majority (>50%) of counties in which published literature has recorded the presence of three ticks of major medical interest, *Ixodes scapularis* Say, *Ixodes pacificus* Cooley and Kohls, and *Amblyomma americanum* Linnaeus. They may

also suggest areas where active surveillance to establish new distribution should be conducted.

Methods

Data collection

From 2014-2019 we collected tick photograph submissions with encounter demographics. TickSpotters participants were instructed on how to take photographs of encountered specimens using proper focus and lighting to highlight key anatomical features (e.g. mouthparts and scutum). Photographs were uploaded to a Wufoo online forms program (SurveyMonkey, Inc. ,2014-2018) or a Salesforce customer relationship management system (2018-2019) where participants were provided a tick identification guide and instructed to provide their best assessment of their specimen to species and life stage. This information allowed TERC researchers to assess a public tick identification accuracy rate. Species options spanned ticks that are endemic to all regions of the United States and included those that are common human and pet biters. These options included blacklegged or deer tick (*I. scapularis*), American dog tick (*Dermacentor variabilis* Say), Lone star tick (*A. americanum*), brown dog tick (*Rhipicephalus sanguineus* Latrieus), Pacific Coast tick (*Dermacentor occidentalis* Marx), western blacklegged tick (*I. pacificus*), Rocky Mountain wood tick (*Dermacentor andersonii* Stiles), Gulf Coast tick (*Amblyomma maculatum* Koch), and Cayenne tick (*Amblyomma cajennese* Fabricius). The user was also instructed to identify the life stage (adult, nymph, or larva), enter the date the tick was found, on whom or what the tick was found (person, pet, or unattached), state of encounter, and

zip code of encounter. For both species and stage there was an "I don't know" option if the user could not choose the tick or the life stage, which would be coded as an "Incorrect" public tick identification. Tick photographs were examined by TERC staff daily and identified to species, stage, and estimated attachment duration, and an email was sent to the participant with the identification confirmation and a risk assessment based on the tick/life stage-specific diseases and prevalence of those diseases for the region of the encounter, as well as prevention education materials.

County-based Mapping

We compared the distribution of 2014-2019 TickSpotters reports to recently published county-level datasets for *I. scapularis*, *I. pacificus*, (Eisen et al. 2016) and *A. americanum* (Springer et al. 2014). Using the comparedf package in R (Joseph 2020), we calculated the total number and percent overlap in TickSpotters reports and existing county reports and the percentage detection by photograph-based passive surveillance. We also noted cases in which TickSpotters identified an established or reported county that was not included in the original reports. We applied the same criteria as in Dennis et al. 1998 to define a county where a tick species was established (at least two different life stages or six individuals of any life stage) versus reported (any single tick of any life stage). Outlier reports (i.e. a submission of a tick far outside its typical range, e.g. *I. scapularis* reported on the west coast or on the continental divide) were removed from tally calculations, but remain on maps to demonstrate the importance of collecting travel history as well as to visualize the possible establishment of new tick species in novel regions. United States county tick distribution maps were created using ArcGIS (www.esri.com).

Results

Nationwide County Distribution

From 2014-2019, the TickSpotters program received 9,532 photograph reports of *I. scapularis* from 901 counties, 692 photograph reports of *I. pacificus* from 1089 counties, and 5,746 photograph reports of *A. americanum* from 993 counties (**Table 1**). TickSpotters identified 197 counties with no previous record of *I.scapularis* presence, 23 counties with no previous record of *I. pacificus*, and 405 counties with no previous record of *A. americanum* (**Table 1**). TickSpotters captured 51.3% of published counties with *I. scapularis* presence, 66.6% of counties with *I. pacificus* presence (Eisen et al. 2017), and 56.1% of published counties with *A. amblyomma* presence (Springer et al. 2014).

TickSpotters detected the greatest expansion of *I. scapularis* in Michigan (21 new counties, 5 established and 16 reported), and Texas (1 established county and 17 reported) (**Table 2**). Other states, including North Carolina, Tennessee, Kentucky, Georgia, and Indiana reported double-digit increases in county presence of *I. scapularis*. (**Table 2**). There were 23 instances of TickSpotters records updating a county from "Reported" under Eisen et al. (2017) to "Established," mostly in Ohio (5 counties updated) and Michigan (4 counties updated) (**Appendix 1**).

Table 1. Total number of U.S. counties with presence of *I. scapularis*, *I. pacificus*, and *A. americanum* based on criteria defining establishment within a county or reported (Dennis et al. 1998) recorded between 2014-2019. Establishment is defined as a county with either two life stages present or at least six individual ticks of any life stage. Reported is defined as at least one occurrence in a county of any recorded tick stage.

Tick Species (TickSpotters)	**Number of Represented Counties (Eisen et al. 2017) (Springer et al. 2014)**			**TickSpotters Reports 2014-2019**					
	Established	**Reported**	**Total Published Counties**	**Established**	**Reported**	**Total TickSpotters Counties**	**Number of published counties captured by TickSpotters (%)**	**Number of published counties not captured by TickSpotters**	**Number of potential TickSpotters newly- identified counties**
Ixodes scapularis (n=9,532)	811	559	1,370	311	590	901	704 (51.3)	666	197
Ixodes pacificus (n=692)	93	15	108	36	66	102	72 (66.6)	30	23
Amblyomma americanum (n=5,746)	620	888	1,508	331	920	1251	846 (56.1)	411	405

Table 2. Newly detected counties with *I. scapularis* presence as reported to TickSpotters photograph-based tick surveillance system between 2014-2019.

State	Number of Counties with New Tick Presence	Tick Species	Established Counties	Reported Counties
Alabama	3	*I. scapularis*	0	3
Arkansas	3	*I. scapularis*	0	3
District of Columbia	1	*I. scapularis*	1	0
Florida	5	*I. scapularis*	0	5
Georgia	12	*I. scapularis*	0	12
Illinois	7	*I. scapularis*	3	4
Indiana	12	*I. scapularis*	3	9
Iowa	6	*I. scapularis*	0	6
Kentucky	15	*I. scapularis*	0	15
Louisiana	3	*I. scapularis*	1	2
Maryland	3	*I. scapularis*	1	2
Michigan	21	*I. scapularis*	5	16
Minnesota	5	*I. scapularis*	1	4
Mississippi	1	*I. scapularis*	0	1
Missouri	9	*I. scapularis*	0	9
Nebraska	3	*I. scapularis*	0	3
North Carolina	15	*I. scapularis*	0	15
New York	1	*I. scapularis*	1	0
North Carolina	2	*I. scapularis*	2	0
North Dakota	1	*I. scapularis*	0	1
Ohio	9	*I. scapularis*	1	8
Oklahoma	2	*I. scapularis*	0	2
Pennsylvania	1	*I. scapularis*	1	0
South Carolina	2	*I. scapularis*	1	1
Tennessee	12	*I. scapularis*	0	12
Texas	18	*I. scapularis*	1	17
Virginia	1	*I. scapularis*	1	0
West Virginia	5	*I. scapularis*	0	5
Wisconsin	6	*I. scapularis*	2	4

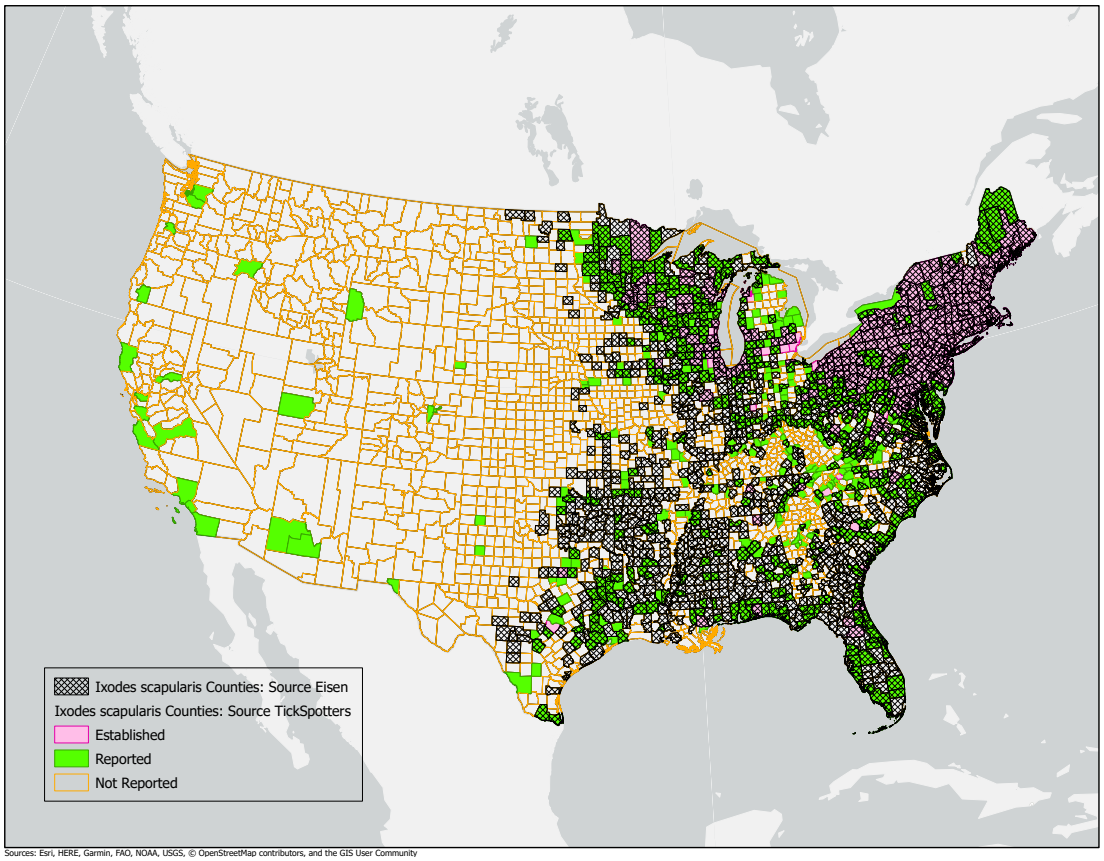

Figure 1. County-level distribution of *Ixodes pacificus* as reported to TickSpotters (2014-2019) compared with Eisen et al. 2017. TickSpotters reported "Establishment" (pink) is defined as a county with either 2 life stages present or at least 6 individual ticks of any life stage. TickSpotters' "Reported" (green) is defined as at least one occurrence in a county of any recorded tick stage (Dennis et al. 1998). Counties with any record of *I. pacificus* as reported by Eisen et al. 2017 is denoted by the black hatch pattern. TickSpotters reports of *I. pacificus* east of the Rocky Mountains were not included in counts due to most likely being travel-related artefact.

Table 3. Newly detected counties with *I. pacificus* presence as reported to TickSpotters photograph-based tick surveillance system from 2014-2019.

State	Number of Counties with New Tick Presence	Tick Species	Established Counties	Reported Counties
Colorado	2	*Ixodes pacificus*	0	2
Idaho	1	*Ixodes pacificus*	0	1
Nevada	1	*Ixodes pacificus*	0	1
Oregon	2	*Ixodes pacificus*	0	2
Utah	2	*Ixodes pacificus*	0	2
Washington	0	*Ixodes pacificus*	0	9

TickSpotters identified over 400 new counties in which *A. americanum* has not previously been reported by Springer et al. 2014 (**Table 1**) (**Fig. 3**). Fifty-three (13%) of the previously unrecorded *A. americanum* counties were classified as established by TickSpotters, **(Appendix 3**), and 150 counties were updated from "Reported" per Springer et al. 2014 to "Established" via TickSpotters reports (**Appendix 3**). The states with the largest expansion in reports were Kentucky (48 new counties; all "Reported"), Illinois (36 new counties; 1 "Established", 35 "Reported"), and Virginia (27 new counties; 11 "Established", 16 "Reported") (**Table 4)**

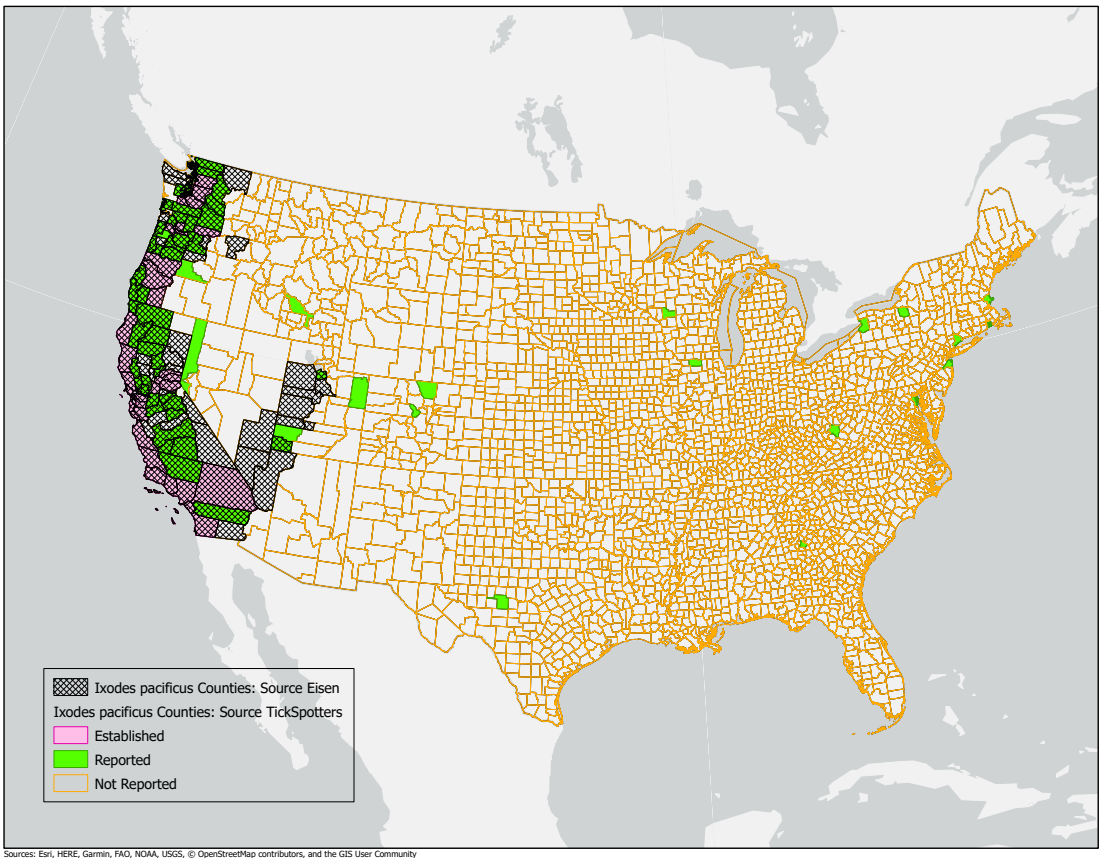

Figure 2. County-level distribution of *Ixodes pacificus* as reported to TickSpotters (2014-2019) compared with Eisen et al. 2017. TickSpotters reported "Establishment" (pink) is defined as a county with either 2 life stages present or at least 6 individual ticks of any life stage. TickSpotters' "Reported" (green) is defined as at least one occurrence in a county of any recorded tick stage (Dennis et al. 1998). Counties with any record of *I. pacificus* as reported by Eisen et al. 2017 is denoted by the black hatch pattern. TickSpotters reports of *I. pacificus* east of the Rocky Mountains were not included in counts due to most likely being travel-related artefact.

Table 4. Newly detected counties with *A. americanum* presence as reported to TickSpotters photograph-based tick surveillance system from 2014-2019.

State	Number of Counties with New Tick Presence	Tick Species	Established Counties	Reported Counties
Alabama	5	*Amblyomma americanum*	1	4
Arkansas	4	*Amblyomma americanum*	0	4
California	6	*Amblyomma americanum*	0	6
Colorado	4	*Amblyomma americanum*	0	4
Connecticut	5	*Amblyomma americanum*	0	5
Florida	6	*Amblyomma americanum*	1	5
Georgia	10	*Amblyomma americanum*	1	9
Idaho	1	*Amblyomma americanum*	0	1
Illinois	36	*Amblyomma americanum*	1	35
Indiana	22	*Amblyomma americanum*	1	21
Iowa	3	*Amblyomma americanum*	0	3
Kansas	19	*Amblyomma americanum*	3	16
Kentucky	48	*Amblyomma americanum*	0	48
Louisiana	6	*Amblyomma americanum*	1	5
Maine	1	*Amblyomma americanum*	0	1
Maryland	7	*Amblyomma americanum*	3	4
Massachusetts	8	*Amblyomma americanum*	1	7
Michigan	4	*Amblyomma americanum*	0	4
Minnesota	8	*Amblyomma americanum*	0	8
Mississippi	2	*Amblyomma americanum*	0	2
Missouri	9	*Amblyomma americanum*	0	9
Nebraska	7	*Amblyomma americanum*	1	6
New Hampshire	3	*Amblyomma americanum*	0	3
New Jersey	10	*Amblyomma americanum*	5	5
New York	6	*Amblyomma americanum*	2	4
North Carolina	23	*Amblyomma americanum*	6	17
North Dakota	1	*Amblyomma americanum*	0	1
Ohio	20	*Amblyomma americanum*	1	19
Oklahoma	14	*Amblyomma americanum*	3	11
Pennsylvania	21	*Amblyomma americanum*	3	18

Rhode Island	2	*Amblyomma americanum*	0	2
South Dakota	1	*Amblyomma americanum*	0	1
South Carolina	6	*Amblyomma americanum*	1	5
Tennessee	13	*Amblyomma americanum*	3	10
Texas	5	*Amblyomma americanum*	0	5
Utah	1	*Amblyomma americanum*	0	1
Vermont	1	*Amblyomma americanum*	0	1
Virginia	27	*Amblyomma americanum*	11	16
West Virginia	14	*Amblyomma americanum*	2	12
Wisconsin	12	*Amblyomma americanum*	0	12

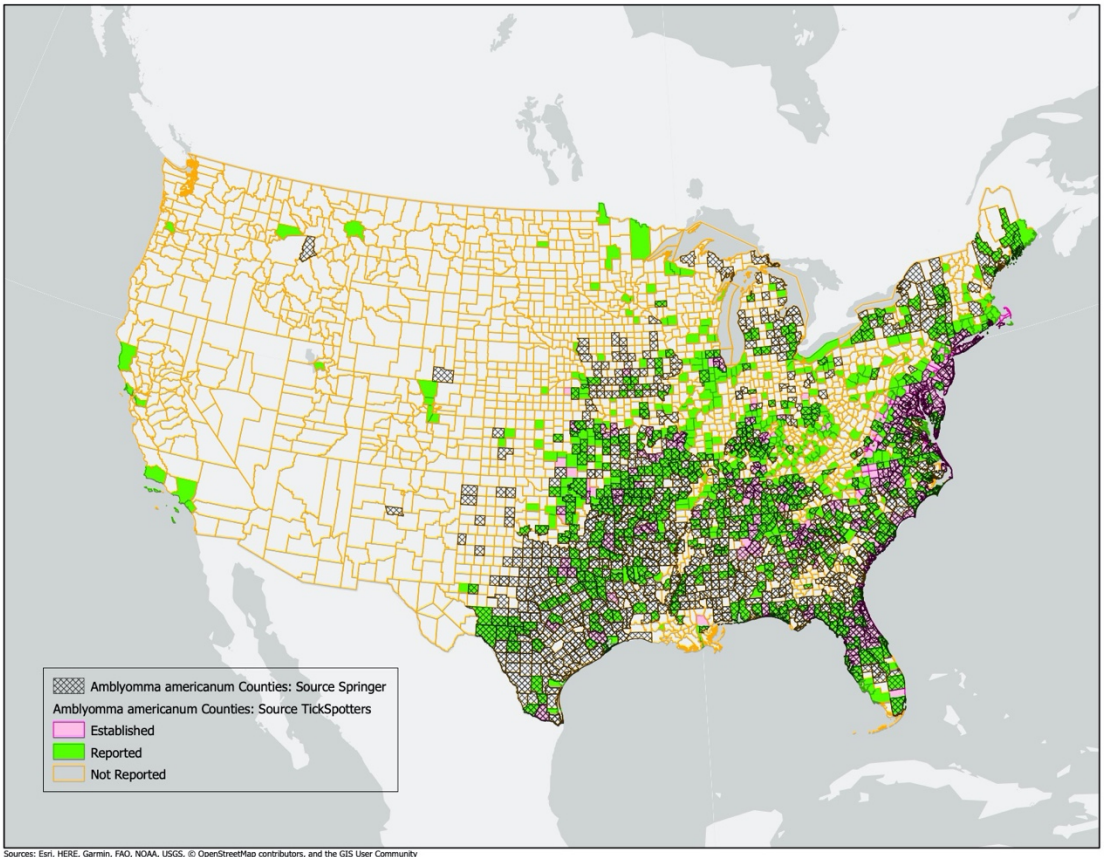

Figure 3. County-level distribution of *Amblyomma americanum* as reported to TickSpotters (2014-2018) compared with Springer et al. 2014. TickSpotters reported "Establishment" (pink) is defined as a county with either 2 life stages present or at least 6 individual ticks of any life stage. TickSpotters' "Reported" (green) is defined as at least one occurrence in a county of any recorded tick stage (Dennis et al. 1998). Counties with any record of *A. americanum* as reported by Springer et al. 2014 are denoted by the black hatch pattern.

Discussion

We compared nationwide photograph-based passive surveillance to recently published counties of presence for three ticks of medical importance. Our analysis supports the prevailing evidence that passive surveillance, and perhaps more importantly citizen science, can play a key role in the pressing need to better understand relationships among tick abundance, socio-ecological, and spatial epidemiology patterns (Eisen et al. 2007; Nieto et al. 2019). While other researchers have demonstrated that crowdsourced in-hand tick submissions have provided a cost-effective means for documenting tick distributions and pathogen prevalence and emergence (Xu et al. 2016; Xu et al. 2018; Xu et al. 2019; Nieto et al. 2019), we found that citizen-submitted photographs also can capture a majority distribution (>50% counties) of these three important species across their range nationwide. However, given that we did not detect the entirety of the known ranges, it is clear that photograph-based surveillance alone does not provide an entire picture of the distribution of tick species of particular concern. We recommend that photograph-based tick surveillance be used in conjunction with other methods and sources of passive tick surveillance to optimize regional tick distribution coverages.

Our results demonstrate considerable spread of the three ticks studied. We reported nearly 200 additional counties of presence for *I. scapularis*, 23 newly documented counties of presence for *I. pacificus*, and over 400 additional counties with presence of *A. americanum*. Most of these new reports represent single submissions from a county so only fall into the "Reported" category, but many of these counties are adjacent to "Established" counties. Counties with the "Established" designation are assumed to have enough ticks to suggest that there is a self-sustaining population of ticks in that county, which may or may not be infected with species-relevant pathogens. Particularly for *A. americanum*, there are

a considerable number of counties where TickSpotters reports document a newly described "Established" designation.

Our results reflect recent studies that have documented an increase in incidence of disease transmitted by these three ticks. Between 2000 and 2014, the number of human cases of Lyme disease in southern Virginia and the northern mountain region of North Carolina rose sharply (Lantos et al. 2015), as did the presence of *I. scapularis* and prevalence of *B. burgdorferi* in field-sampled ticks in the Tennessee Valley (Hickling et al. 2018) demonstrating the spread of Lyme disease risk into the southeastern states. Given the recent increase in reported *Ehrlichia* (Mogg et al. 2016) and spotted fever rickettsial illnesses (Dahlgren et al. 2016), seemingly due to the expansion of *A. americanum*, our results also reinforce the need for public health officials to be aware of the presence of this tick in their locale. Information based on our results for each of these tick species can be disseminated by public health officials or designees to area physicians and veterinarians and other stakeholders who otherwise may not be aware of the potential for tickborne disease related to these species. Cooperative Extension departments at state universities as well as county recreation departments, and local health departments may also make use of these results to educate their citizens on potential disease risks as well as on effective tick bite prevention strategies.

At the time these data were collected, we did not routinely collect travel history information. Occasionally, submitters would include a note regarding travel that would allow us to make a more likely species identification, but the zip code recorded was often that of the residence and not the encounter location. Sometimes participants would not know where the tick was encountered. This is a known limitation to passive surveillance,

but also demonstrates how easily ticks can be transported to new locations. Our current surveillance system now collects information on recent travel history.

Passive surveillance cannot entirely replace active tick surveillance. It can, however, provide a more targeted strategy for selecting new areas for *in situ* sampling, thus aiding in cost-efficiency. Future work using passively collected tick data from photographs should incorporate environmental and host variables important to tick distributions and disease risk like habitat fragmentation and key hosts (Estrada-Peña 2009), vegetation composition, temperature, humidity (Johnson et al. 2018; Ginsberg et al. 2020) (e.g. tick adverse moisture events (Berger et al. 2014a)), and sociological demographics. Comparisons and collaboration with habitat suitability prediction models should be ongoing to update model parameters (Hahn et al 2016). Additionally, combining passively collected data from photographs with spatiotemporal models of existing disease cases can further hone the ability to predict future infection risk and identify areas needing more targeted prevention education (Pepin et al. 2012; Li et al. 2014). Should photograph-based tick surveillance become a widely-used tool, it may be possible for machine learning and artificial intelligence to be utilized for increasing the accuracy of identification as well as speed of processing, similar to what has been found for mosquito larvae (Sanchez-Ortiz et al. 2017) and arthropod biodiversity studies (Lytle et al. 2010).

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Manuscript 5

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Tick-borne disease prevention behaviors among participants in a citizen science photograph-based passive tick surveillance system

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Abstract

Theory-based approaches to health communication and behavior are increasingly being applied to interventions that address gaps in public tickborne disease prevention knowledge and practices. We sought to understand the tickborne disease prevention behaviors among participants in a crowdsourced tick surveillance system (TickSpotters) that provides rapid responses consisting of tailored, theory-based messages about tick bite risk and prevention strategies. We administered an electronic survey to a randomly selected sample of TickSpotters participants and compared their responses to those from a nationwide sample of Master Gardeners (MG), a group with heighten tick exposure due to their outdoor activity. Over 80% of TickSpotters respondents, and over 75% of MG respondents encountered a tick in the past year. Among both groups, tick checks were the most frequently practiced prevention behavior, with over 70% of people reporting that they perform them most or all of the time after outdoor activity. A greater proportion of MGs used skin repellents such as DEET or picaridin than TickSpotters users, but more than 70% of respondents from both groups reported that they never or only sometimes use permethrin-treatment on clothing, and nearly half of both groups reportedly used no peridomestic tick treatments. TickSpotters respondents overwhelmingly reported recording tick encounter information and saving specimens for identification and testing, while only a small percentage of MGs catalogued their tick encounters. These findings suggest that while both TickSpotters and MG groups appear to be practicing some important tick bite prevention behaviors, there remain areas that could benefit from targeted theory-based interventional approaches.

Introduction

Despite widespread education initiatives in tick-endemic regions, numerous studies demonstrate that overall public perception and knowledge surrounding tick identification, tickborne disease risk, and proper disease prevention strategies is low, and that even when knowledge is present, prevention practices still lag (Shadick et al. 1997; Jones et al. 2002; Herrington 2004; Valente et al. 2014; Butler et al. 2016). This is particularly troubling as distributions of tick vectors and associated pathogens are expanding, and tickborne diseases have more than doubled in the past decade (Rosenberg et al. 2018; Eisen and Eisen 2019). Evidence demonstrates, however, that employing theory-based approaches is an effective way to improve both perceptions and intentions regarding tickborne disease prevention behaviors (Daltroy et al. 2007; Mowbray et al. 2012; Aenishaenslin et al. 2015; Tengland 2016; Butler et al. 2016; Beaujean et al. 2016). In particular, the Health Belief Model (HBM)/Protection Motivation Theory (PMT) and theory of planned behavior (TPB) are appropriate health communication constructs for predicting improved outcomes in performance of prevention behaviors based on several interrelated components (Rosenstock 1966; Prentice-Dunn & Rogers 1986; Ajzen 1991).

Health Belief Model (HBM)/Protection Motivation Theory (PMT) and Theory of Planned Behavior (TPB) are well-established as effective predictors of activating prevention behaviors based on the degree of a person's perception of risk and benefits resulting from behavior change, and their perceived barriers to taking the recommended action (Rosenstock 1966, Jones et al. 2014). Some theory-based educational prevention programs have been successfully used to increase tick-bite prevention behaviors (use of repellent, tick checks, tick habitat avoidance) and reduce the incidence of tickborne infection (Daltroy et al. 2007). However, a systematic review of education and

communication interventions to prevent tickborne illness found only nine total studies investigating the use of prevention-based applications for tickborne disease, and only three that were randomized control trials. While several demonstrated positive behavior change, most relied only on self-reporting to determine change in behavior (Mowbray et al. 2012). Additionally, another systematic review of HBM-based programs identified perceived benefit and perceived barriers to action as the strongest predictors of adherence to health behaviors (Jones et al. 2014). No studies to date have investigated the use of theoretical behavior change messages embedded within a passive tick encounter surveillance program to assess their role in capitalizing on the increased engagement of people who have recently encountered a tick, and whether any immediate behavior changes are long-lasting.

The HBM predicts likelihood of a health-promoting behavior based on four main factors: perceived susceptibility to a health-related event (e.g. tick bite), perceived severity of that encounter (e.g. likelihood of acquiring a tickborne disease, and the seriousness of that disease), perceived benefits (e.g. whether taking preventative measures will successfully avoid the tick bite or disease), and perceived barriers (e.g. degree of difficulty of performing prevention behaviors, or cost associated with prevention products) (Rosenstock 1966). Developed as an extension of this model, the PMT frames self-protection as the proximal motivation to adopting the behavior (Rogers 1975; Prentice-Dunn & Rogers 1986). These perceptions can be modified by external and internal motivators (cuing action to perform the behaviors, and the level of self-efficacy a person has about performing the behavior), which are where interventions are most often targeted. Similarly, the TPB predicts health-protective behavior based on attitudes that influence intention to perform the behavior, and that ultimately, perceptions of behavioral control determine behavior (Ajzen 1991). Meta-analyses comparing studies across these theories

have identified that perceived severity is the weakest determinant of health behavior adoption while lowering perceived barriers to action is the strongest predictor of behavior adoption (Carpenter et al. 2010; McEachan et al. 2011). The lower the barrier to adoption, the more likely the behavior will be adopted. Specific to the TPB, perceived susceptibility often influences intention to act, but does not translate to adoption of a health-protective behavior (McEachan et al. 2011). Addressing the barriers to adopting prevention actions should be a central target in most health promotion campaigns.

Since 2014, the University of Rhode Island (URI)'s TickEncounter Resource Center has hosted TickSpotters, a crowdsourced photograph-based tick surveillance system. TickSpotters provides the public with an opportunity to submit photographs of encountered ticks through an online survey platform, to receive an expert identification confirmation of tick species and stage, a feeding duration estimate, and overall personalized riskiness assessment for no charge. Using contextual communication (Gross 1994) by applying the message to meet the specific needs and concerns of the participant, these tailored responses also provide science-based suggestions for avoiding future tick encounters (Kopsco et al. *in review* a). The program has a broad reach, receiving over 50,000 submissions between 2014-2018 from every U.S. state, six Canadian Provinces, and several Mexican states. Researchers are increasingly relying on citizen science-sourced vector distribution and disease data (Hines & Sibbald 2015; Xu et al. 2016; Palmer et al. 2017; Lewis et al. 2018; Nieto et al. 2018; Xu et al. 2018; Xu et al. 2019), and recent evidence supports the accuracy of using either standardized or non-standardized photographs to identify ticks when compared to the "gold standard" identification under microscope visualization (Koffi et al. 2017; Kopsco et al. *in review b*). The capacity for this novel crowd-sourced database to be used as both a surveillance tool that can identify tick population trends and potential new

tick foci, and a robust public health communication pathway that improves tickborne disease prevention behaviors via social cognitive theory (Bandura 2001) is not yet assessed. In addition to educational and contextual dialogue, these tools provide specific and practical prevention suggestions that serve as potential "cues to action" for altering perceptions of susceptibility and severity related to tick bites, overcoming perceived barriers to action, and encouraging ultimate behavior change beyond just intention (Carpenter 2010). For example, rather than suggest that people "use insect repellent," TickSpotters messages are specific about the type of effective acaricides one should use, as well as when to apply them to both humans and pets. This surveillance tool targets the goals set by the 2014 Federal Tick-Borne Disease Integrated Pest Management Workgroup Initiative, specifically by addressing the need for evidence-based tool-kits and other resources on prevention best practices for state and local public health partners, to educate the public on specific strategies they can take to reduce risk of exposure to tickborne diseases, and to develop and share information regarding landscape risk to reduce tick encounters (Beard & Strickman 2014).

We sought to identify tickborne disease prevention behaviors among participants in the TickSpotters program and compare them to those of Master Gardeners (MGs), a population with a high likelihood of tick bite exposure due to extensive outdoor activity, but who generally have not been a target of the public health messaging from TickSpotters emails. In particular, we were interested to better understand whether participation in the TickSpotters theory-based approach to prevention communication was associated with greater adherence to science-based prevention behaviors when compared to another high risk group within the general public. Our survey was designed to detect whether participants felt that the TickSpotters program had increased their adoption of tick-bite prevention

behaviors, and to expose gaps in knowledge or action to preventing tick bites that still persisted among members of this group. We hypothesized that exposure to TickSpotters' health communication messaging improved tick bite prevention behavior adherence, and that TickSpotters users would be more informed about ticks than MGs, despite MG's likely greater exposure to ticks via outdoor gardening activities.

Methods

In October 2019 we administered an electronic survey (Qualtrics, Inc.) (**Appendix 6**) to a randomly selected sample (n=10,000) of TickSpotters participants via the email address provided in their most recent submission, as well as distributed a web link to MGs through regional Cooperative Extension listservs. MGs were chosen as a comparison group because they engage in outdoor activities that expose them to tick bites in peridomestic and wooded tick habitats, and we assumed that they are a sub-group of the general public who would be engaged in tick bite protection to at least a similar baseline level as those who submit TickSpotters reports. The national distribution of MGs also made them an appropriate comparison group since TickSpotters reports are sourced from across the United States. To ensure the two surveyed groups were entirely separate, TickSpotters participants who were also MGs were excluded, and MGs who had submitted a TickSpotters report were also excluded. With the exception of specific questions to TickSpotters participants regarding their experience using the program, the surveys provided to these two groups were identical.

Survey participants were asked to identify trusted sources of prevention information and were presented with several questions that explored their attitudes about the safety of acaricides and pyrethroid yard treatments, as well as their understanding of

how tickborne illnesses are transmitted. We asked questions that assessed adherence to prevention behaviors including daily tick checks, wearing permethrin-treated clothing, employing yard precautions (acaricide treatments and/or ecological tick habitat abatement), and using pet protection. Other important metrics that were assessed included whether TickSpotters participants encountered fewer ticks following their engagement with the program, found ticks more quickly (before engorgement), and had fewer incidences of tickborne illness. We also presented survey participants with photographs of commonly encountered ticks to assess whether usage of the TickSpotters program was associated with more accurate tick recognition. Their experience with tickborne illness was also assessed. We conducted Pearson's chi-square analyses to assess whether there were differences in responses between the TickSpotters and Master Gardener groups. The survey was approved and overseen by the University of Rhode Island Institutional Review Board.

Results

Demographics

Between October 2019 and January 2020 we received 634 survey responses from TickSpotters participants, and 734 responses from MGs. Nearly 50% (49.2%) of MGs had held their certification between three and 10 years, and a quarter (24.5%) have been MGs for more than 10 years. TickSpotters survey participants represented a similar racial distribution as MG respondents but had a statistically different gender distribution than MGs (χ^2 = 70.80, df=4, p<0.001) and represented a greater proportion of households with at least one child at home (38.9% versus 8.5% respectively; χ^2 = 168.79, df=5, p<0.001) (**Table 1**). A greater proportion of TickSpotters users worked full-time while MGs were

mostly retired (52% vs. 62.9% respectively; χ^2 = 269.59, df=6, p<0.001) (**Table 1**). TickSpotters participants held fewer graduate and advanced degrees than MGs (χ^2 = 39.30, df=7, p<0.001), but there was no difference in income between the two groups (χ^2 = 5.32, df=7, p=0.62). The two groups proportionally represented different regions of the country. While there was broad survey response nationwide, the largest proportion of MG respondents (30.1%) resided in Northeastern states (CT, ME, MA, NH, RI, VT), while the greatest proportion of TickSpotters respondents (33.3%) were from Mid-Atlantic states (DE, DC, MD, NJ, NY, PA, VA) (χ^2 = 728.92, df=46, p<0.001) (**Table 1**). TickSpotters respondents predominantly lived in suburban areas (40.8%) and MGs resided primarily in rural areas (47.5%; χ^2 = 38.98, df=2, p<0.001) (**Table 1**). Slightly less than half (45.6%) of TickSpotters respondents reported either suffering from or knowing someone personally who suffers from symptoms of "chronic Lyme disease," a result reported by 40% of MGs (χ^2 = 3.79, df=1, p=0.05). Sixty-five percent of MGs had no record of tickborne illness diagnosis in their household, while 62% of TickSpotters respondents reported that no one in their household has ever been diagnosed with a tickborne disease. Nearly 70% of TickSpotters respondents sent only a single report to the program (the mean number of TickSpotters reports submitted by an individual between 2014 and 2018 was 1.42 (68.9%) (mean = 1.42, max = 5, SD = 0.74).

Table 1. Demographics of TickSpotters (n=634) and Master Gardener (n=734) survey respondents.

	TickSpotters	Master Gardeners
Total number of respondents (%)	634 (46.3)	734 (53.7)
Gender	n = 585	n = 657
Female	389 (66.5)	549 (83.6)
Male	189 (32.3)	99 (15.1)
Transgender	0	0
Nonconforming	2 (0.34%)	1 (0.15)
Prefer not to answer	5 (0.85)	8 (1.2)
At least one child (17 or younger) in the home	n = 591	n = 658
	230 (38.9)	56 (8.5)
Employment status	n = 592	n = 657
Full-time (35 or more hrs./week)	311 (52.5)	122 (18.6)
Part-time (fewer than 35 hrs./week)	76 (12.8)	89 (13.5)
Retired	121 (20.4)	413 (62.9)
Unemployed/Job-hunting	13 (2.2)	6 (0.91)
In school	12 (2.0)	2 (0.03)
Disabled/Not looking for work	38 (6.4)	10 (1.5)
Prefer not to answer	21 (3.5)	15 (2.3)
Education	n = 595	n=662
High school/GED	35 (5.9)	15 (2.3)
Some college	77 (12.9)	67 (10.1)
Associate degree (2-year)	51 (8.6)	47 (7.1)
Bachelor's degree (4-year)	215 (36.1)	207 (31.3)
Master's degree	138 (23.2)	251 (37.9)
Doctoral degree	45 (7.6)	41 (6.2)
Professional degree (MD, JD)	23 (3.9)	29 (4.4)
Prefer not to answer	11 (1.9)	5 (0.76)
Region of Residence	n = 594	n= 657
Northeast	121 (20.4)	198 (30.1)
Southeast	51 (8.6)	178 (27.1)
Midwest	96 (16.2)	162 (24.6)
Mid-Atlantic	198 (33.3)	77 (11.7)
Mountain	13 (2.2)	32 (4.9)
Southwest	17 (2.9)	4 (0.6)
North Central	2 (0.3)	4 (0.6)
Pacific	66 (11.1)	1 (0.2)
Non-contiguous	0	1 (0.2)
Outside of the US	30 (5.1)	0
Peridomestic Environment	n = 595	n = 653
City	82 (13.8)	52 (7.9)
Small town	87 (14.6)	84 (12.9)
Suburban	243 (40.8)	207 (31.7)
Rural	183 (30.8)	310 (47.5)
Race (more than one possible)	n = 681	n=794
White	535 (78.6)	621 (78.2)
Black/African/Caribbean American	2 (0.3)	4 (0.5)
American Indian or Alaskan Native	8 (1.2)	6 (0.8)
Asian	18 (2.6)	4 (0.5)
Native Hawaiian or Pacific Islander	1 (0.2)	0
Other	84 (12.3)	130 (16.4)
Prefer not to answer	33 (4.9)	29 (3.6)
Annual Income	n = 577	n=626
Less than $50,000	83 (14.4)	87 (13.9)
$50,000-$99,000	131 (22.7)	159 (25.4)
$100,000-$149,000	96 (16.6)	106 (16.9)
$150,000-$199,000	40 (6.9)	40 (6.4)
$200,000 and above	43 (7.5)	31 (4.9)
Prefer not to answer	184 (31.9)	203 (32.4)

Tick-borne disease prevention resources

TickSpotters and MG survey respondents reportedly sought tick-bite prevention information from different sources (χ^2 = 481.65, df=200, p<0.001). TickSpotters users said that they rely on prevention information from the TickEncounter Resource Center or other academic-based sites (27.8%), the CDC (15.9%), and WebMD or other mainstream medical websites (14.5%). About 10% of TickSpotters users (10.9%) also sourced tickborne disease prevention information from family and friends. MGs sourced their tick-bite prevention information mostly from the Centers for Disease Control and Prevention (CDC) (18%), a university or academic-based resource including Cooperative Extension resources (15.7%), or WebMD or other mainstream medical websites, including veterinary sites (14.5%). Just over 10% (11.8%) reported getting tick-bite prevention information from friends and family. Less than 10% of respondents in both groups reported seeking tick-bite prevention information from social media, "Lyme-literate physicians," specific Lyme disease-focused organizations, or their primary care physicians.

Tick-borne disease prevention behaviors

Over 60% of TickSpotters respondents reported that they either "Never" or only "Sometimes" use tick repellent with DEET on their skin when engaging in activities in tick habitat compared to MGs (χ^2=10.85, df=4, p=0.02) (**Table 2**), who, overall, were more likely to use DEET most (residual=1.12, range=[-1.52-1.21]) or all of the time (residuals=1.21; range=[-1.52-1.21]). There was no difference between TickSpotters and MG respondents in their reported wearing of long pants when in tick habitat (χ^2=8.47, df=4, p=0.07), but MGs were strongly associated with mostly (residual=1.82; range=[-1.99-1.82]) and "Always" (residual=1.28; range=[-1.99-1.82]) tucking pants into socks (χ^2=19.61, df=4, p<0.001) (**Table 2**). Over 70% of both TickSpotters users (**Table 2**) and

MGs (**Table 3**) reported that they "Never" or only "Sometimes" use tick repellent containing permethrin on their clothing (χ^2=4.37, df=4, p=0.35). Three-quarters of TickSpotters users reportedly perform tick checks on themselves after time outdoors "Most of the time," (33.1%) or "Always" (43.9%), but only performed tick checks on children or pets approximately 70% of the time (**Table 2**). There was no difference between how often TickSpotters respondents and MGs performed tick checks on themselves (χ^2=8.83, df=4, p=0.06), or on their family and pets (χ^2=3.25, df=4, p=0.51). TickSpotters respondents were strongly associated with "Always" avoiding walking along trail edges where ticks are likely to be encountered (residual=1.40; range=[-2.13-1.40]), while MGs were strongly associated with "Never" avoiding the edge (residual=2.04; range = [1.34-2.04]) (χ^2=14.6, df=4, p=0.005).

Table 2. Performance frequency of commonly recommended tick-bite prevention behaviors by TickSpotters participants.

Field	Never	Sometimes	About half the time	Most of the time	Always	Total
Use a tick repellent with DEET on exposed skin before working or playing in tick habitat?	28.46% 175	34.80% 214	11.06% 68	18.86% 116	6.83% 42	615
Wear long pants when entering a tick-infested area?	2.11% 13	19.94% 123	11.35% 70	30.63% 189	35.98% 222	617
Tuck your pants into socks to keep ticks on the outside of clothes?	38.05% 234	26.50% 163	7.80% 48	15.12% 93	12.52% 77	615
Use a tick repellent that contains permethrin on your clothing?	44.59% 272	26.72% 163	9.34% 57	11.31% 69	8.03% 49	610
Check yourself for ticks after being outdoors?	1.14% 7	12.05% 74	9.93% 61	33.06% 203	43.81% 269	614
Avoid areas that may have ticks (trail edges, etc)?	13.52% 83	28.50% 175	14.98% 92	30.13% 185	12.87% 79	614
Check children/pets for ticks after outdoor activity?	5.89% 35	14.14% 84	10.10% 60	28.62% 170	41.25% 245	594

Table 3. Performance frequency of commonly recommended tick-bite prevention behaviors by Master Gardeners.

Field	Never	Sometimes	About half the time	Most of the time	Always	Total
Use a tick repellent with DEET on exposed skin before working or playing in tick habitat?	22.29% 150	33.43% 225	11.59% 78	23.03% 155	9.66% 65	673
Wear long pants when entering a tick-infested area?	2.09% 14	15.80% 106	8.35% 56	33.23% 223	40.54% 272	671
Tuck your pants into socks to keep ticks on the outside of clothes?	28.79% 192	24.44% 163	8.85% 59	21.44% 143	16.49% 110	667
Use a tick repellent that contains permethrin on your clothing?	40.12% 268	27.69% 185	9.43% 63	14.67% 98	8.08% 54	668
Check yourself for ticks after being outdoors?	3.00% 20	13.79% 92	7.65% 51	30.28% 202	45.28% 302	667
Avoid areas that may have ticks (trail edges, etc)?	20.33% 136	30.19% 202	13.45% 90	26.76% 179	9.27% 62	669
Check children/pets for ticks after outdoor activity?	7.45% 48	16.61% 107	8.85% 57	27.95% 180	39.13% 252	644

Overall there were no statistically significant differences between the two groups in the frequency of using current methods of tick bite prevention (χ^2 = 235.33, df=441, p=0.98). The most frequently-reported current methods of tick bite prevention used by TickSpotters respondents were saving a tick to be tested later (18.1%), and using EPA-approved skin repellents containing picardin or DEET (12.9%). Forty-four percent of TickSpotters respondents use no peridomestic treatment methods to prevent ticks. Among MG respondents, the most frequently-reported current methods of tick bite prevention

included applying EPA-approved insect repellents (16.8%), tucking pants into socks when in tick habitat (12.3%), and wearing light-colored clothing in tick habitat (10.9%) (**Table 4**). Only 2.5% of respondents said that they currently wear permethrin-treated clothing (**Table 4**), and over half of MG respondents (53.4%) do not use any type of yard acaricide, either synthetic or "natural."

Table 4. Currently-used prevention methods (% and number) as reported by TickSpotters (TS) and Master Gardeners (MG).

METHOD	TS		MG	
Daily tick checks	9.60%	270	9.68%	262
At-home treatment of clothing with permethrin spray	5.97%	168	5.39%	146
Purchasing and wearing pre-treated permethrin clothing	2.84%	80	2.55%	69
Treating yards with synthetic pesticides (e.g. bifenthrin)	3.20%	90	1.81%	49
Treating yards with natural/organic pesticides (e.g. cedar oil)	2.81%	79	1.63%	44
Tucking pants into socks when in tick habitat	8.14%	229	12.34%	334
Wearing light-colored clothing when in tick habitat	7.04%	198	10.97%	297
Chewable pet preventative (e.g. Bravecto, NexGard, Simparica)	6.61%	186	7.17%	194
Collar pet preventative (e.g. Seresto, Preventic)	3.06%	86	3.03%	82
Natural pet preventatives (e.g. Sentry, essential oils)	2.42%	68	1.33%	36
Bug spray containing EPA-approved repellent (e.g. DEET, picaridin)	12.90%	363	16.88%	457
Natural/organic bug spray repellent	7.57%	213	7.98%	216
Saving a tick to be identified or tested later	18.09%	509	8.09%	219
Other	2.42%	68	2.14%	58
Topical pet preventative (e.g. Frontline, K9 Advantix)	7.00%	197	8.16%	221
None	0.32%	9	0.85%	23

Tick bite management

TickSpotters respondents, on the whole, abided by expert-recommended tick bite management strategies more so than did MGs. Over 80% of TickSpotters respondents, and over 75% of MG respondents encountered a tick in the past year (**Fig. 1**), but 51.9% of TickSpotters respondents and 77.5% MG respondents sought no health care provider

immediately (physician or veterinarian) after the tick was found (χ^2=39.15, df=2, p<0.001). Upon finding an attached tick, roughly 90% of both TickSpotters (**Table 5**) and MG respondents indicated that they "Always" remove ticks immediately (χ^2=2.37, df=4, p=0.66). However, TickSpotters respondents, as opposed to MGs, were strongly associated with "Never" using their fingers to remove a tick (57.6%; χ^2=20., df=4, p<0.001; residual=2.23; range=[-1.22-2.23]), and never applying topical substances to remove an attached tick (87.4%; χ^2 = 43.1, df=4, p<0.001; residual=1.92; range=[-3.37-1.92]) (**Table 5**). Over 50% of TickSpotters respondents said that they use pointy tweezers to remove an attached tick either "Most of the time" or "Always," (54.2%), while MGs are more strongly associated with only "Sometimes" using pointy tweezers to remove ticks (χ^2=22.80, df=4, p<0.001). TickSpotters respondents more frequently saved the tick for later identification or testing (64.6%; residual=6.71; range=[-11.10-6.72] (**Table 5**), and recorded the date of the encounter (67.3%), while over half of MGs reported that they did not tend to save their tick nor record information about the encounter (χ^2=373.87, df=4, p<0.001) (**Table 6**). Nearly half (46.6%) of TickSpotters survey participants reported anxiety from their tick encounters either "Most of the time" or "Always" (**Table 5**). TickSpotters respondents were more strongly associated with experiencing anxiety related to a tick encounter (residual = 5.29; range=[-4.25-5.29], while MGs were not (χ^2=117.3, df=4, p<0.001; residual=2.23; range=[-1.22-2.23]) (**Tables 5, 6**).

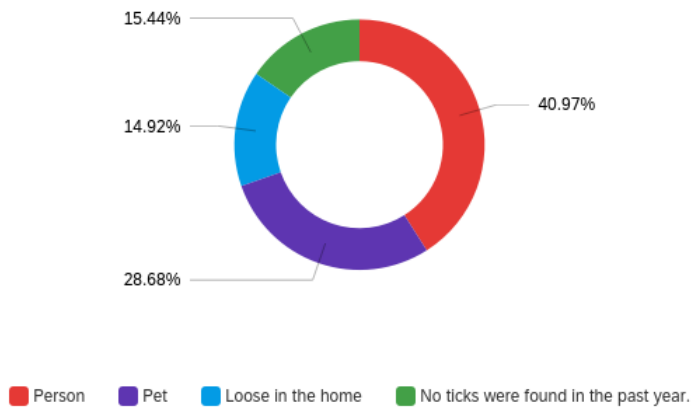
Table 5. Percentage frequency of behaviors performed among TickSpotters respondents upon finding a tick on themselves, a family member, or a pet.

Field	Never	Sometimes	About half the time	Most of the time	Always	Total
Remove the tick immediately?	0.97% 6	0.49% 3	0.97% 6	6.48% 40	91.09% 562	617
Use your fingers to remove the tick?	57.59% 353	18.11% 111	6.36% 39	11.75% 72	6.20% 38	613
Apply oils or other substances to get the tick to "back out?"	87.44% 536	6.85% 42	1.14% 7	1.63% 10	2.94% 18	613
Use pointy tweezers to remove the tick?	20.62% 127	18.83% 116	6.33% 39	20.94% 129	33.28% 205	616
Save the tick for later identification or testing?	5.18% 32	23.46% 145	6.80% 42	20.55% 127	44.01% 272	618
Immediately contact a physician?	46.63% 284	29.23% 178	4.60% 28	7.88% 48	11.66% 71	609
Record the date it was found and watch for symptoms?	12.52% 77	15.12% 93	5.04% 31	14.80% 91	52.52% 323	615
Experience anxiety about potential tick-borne illnesses?	11.71% 72	32.03% 197	9.59% 59	18.37% 113	28.29% 174	615

Table 6. Percentage frequency of behaviors performed among Master Gardener respondents upon finding a tick on themselves, a family member, or a pet.

Field	Never	Sometimes	About half the time	Most of the time	Always	Total
Remove the tick immediately?	0.91% 6	0.60% 4	0.45% 3	8.01% 53	90.03% 596	662
Use your fingers to remove the tick?	45.14% 297	24.01% 158	7.29% 48	14.74% 97	8.81% 58	658
Apply oils or other substances to get the tick to "back out?"	73.89% 481	15.82% 103	3.38% 22	4.15% 27	2.76% 18	651
Use pointy tweezers to remove the tick?	20.12% 132	27.44% 180	8.38% 55	20.58% 135	23.48% 154	656
Save the tick for later identification or testing?	52.13% 343	21.12% 139	3.95% 26	7.14% 47	15.65% 103	658
Immediately contact a physician?	65.65% 430	20.61% 135	3.82% 25	3.05% 20	6.87% 45	655
Record the date it was found and watch for symptoms?	36.59% 240	18.60% 122	4.12% 27	14.02% 92	26.68% 175	656
Experience anxiety about potential tick-borne illnesses?	26.30% 172	44.50% 291	8.72% 57	10.24% 67	10.24% 67	654

A.



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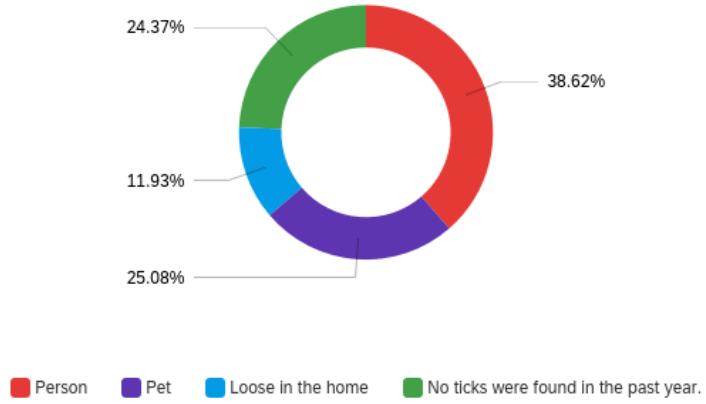

Figure 1. **A)** Percentage of tick encounters reported by TickSpotters respondents (n = 952) compared to, **B**) the percentage of tick encounters reported by Master Gardener respondents (n = 989) in the past year.

Tick identification ability

Both TickSpotters respondents and MGs displayed poor tick identification skill and knowledge regarding season of activity. Nearly 40% of TickSpotters respondents and almost one-third (31%) of MG respondents incorrectly identified tick species other than *I. scapularis* as being able to transmit Lyme disease-causing bacteria. Less than half (43.7%) of TickSpotters respondents, and approximately one-third (34.4%) of MGs correctly identified an adult female *D. variabilis*. A third of TickSpotters respondents misidentified the season of nymphal *I. scapularis* activity, and one-quarter said that they did not know when nymphal *I. scapularis* were active. Nearly 30% (29.2) of TickSpotter survey participants correctly identified when adult *I. scapularis* were active (fall and winter months), and 27.2% reportedly did not know when adult *I. scapularis* ticks were active. Only one-third (34.4%) of MGs correctly identified the season of activity of *I. scapularis* nymphs, while 32.9% reported that they did not know when they were active. Only one-quarter (25.3%) of MGs correctly identified the fall and winter months as when adult *I. scapularis* are active.

Discussion

We compared tick-borne disease prevention behaviors among two groups representing predominantly Lyme-endemic regions with similar tick exposure. Our results demonstrate that both groups exhibit low rates of consistent tick bite prevention behaviors and strategies like applying skin (e.g. DEET) and clothing (e.g. permethrin) repellents, tick checks, and tick habitat avoidance despite reported reliance on scientific and academic-based resources for prevention information. These results are consistent with other data that demonstrate that people who are connected to academic sources of

science-based tickborne disease information reportedly rely and seek out information from these sources, but often still fail to adhere to recommended behaviors, like wearing permethrin-treated clothing (Kopsco et al. *in review a*). However, compared to MGs, TickSpotters respondents' behavior upon finding an attached tick is much more consistent with expert recommendations. The majority of TickSpotters respondents reported proper tick removal, that they save the tick for identification or pathogen testing, and record information about the encounter and watch for symptoms. The majority do not immediately contact a physician.

TickSpotters users reported a much higher frequency of anxiety related to tick encounters than MG, which could indicate a greater perception of tick-borne disease severity and susceptibility, or it could be that they are TickSpotters users due to their anxiety related to tick bites. A study that examined self-reported use of personal protective measures (PPMs) found that applying insect repellent to skin and tick checks were protective against tick-borne disease diagnosis (Kianersi et al. 2020). Similarly, Niesobecki et al. (2019) found overall low usage of skin and clothing repellents among respondents, but that those who had greater knowledge about Lyme disease, as well as higher perceived severity and susceptibility to the illness were more likely to treat their yards with acaricide. However, the use of chemicals appears to be driven by income (Niesobecki et al. 2019), so one's socioeconomic status could very well be a barrier to action in many cases of lacking prevention behavior. Though in this study, the two groups did not differ in income distribution.

Both TickSpotters participants and MGs reported reluctance in use permethrin-based acaricides on clothing, which could be directly linked to a concern about harming pollinators in the case of MGs, or that these pesticides pose a risk to children in the case

of TickSpotters respondents (Peterson 2000). The advent of non-target and biological control methods for tick reduction, such as *Metarhizium anisopliae* (e.g. Met52), tick tubes (e.g. Damminix), and rodent bait boxes provides alternative methods to the usage of potentially harmful pyrethroid perimeter treatments. However, a recent study that found a lack of common usage of these alternative methods in Lyme-endemic states suggests that commercial pest control companies are not widely aware of these alternatives or consider them to be cost-prohibitive to offer to clients (Jordan and Schultze 2019).

We identified two main areas for targeted education intervention in this study, specifically improving public tick identification and the use of repellents. Both TickSpotters and MG participants demonstrated poor recognition of common tick species (Falco et al. 1998, Kopsco et al. *in review a*), and their seasons of activity (Kopsco et al. *unpublished manuscript*). These two gaps in knowledge can put both humans and their pets at risk of tick-borne illness because of a lack of awareness of when ticks will be encountered, and either false security (e.g. cold weather), or false alarm (e.g. all ticks transmit Lyme disease). However, both groups report frequent tick checks on themselves as well as children and pets, so regular reminders from veterinarians or public health officials about when during the year and where on humans and pets the checks should focus could improve quick detection of any attach ticks.

To address concerns and improve adoption of prevention behaviors using effective repellents like permethrin and DEET, we recommend the application of theory-based approaches that use contextual communication within public engagement (Gross 1994). Daltroy et al. (2007) found in a randomized control trial that humor-based interactive communication directed toward people traveling to a Lyme-endemic vacation

areas in Massachusetts resulted in improved knowledge of how to prevent tick bites as well as increased usage of repellents and performance of tick checks over a control group. This intervention employed aspects of the Health Belief Model (Rosenstock 1974) as well as the Theory of Planned Behavior (Azjen 2011) by demonstrating tick removal behaviors to persuade a group that they are capable of performing them themselves (i.e. self-efficacy), and provided tools that overcame barriers to action (e.g. tick identification cards, coupons to purchase tweezers and repellent, etc.). We suggest employing prevention engagement interventions that incorporate behavior modelling as well as similar tools to create easier access to repellent products and proper tweezers for tick removal.

Limitations to this study include inherent sampling bias in who participates in the TickSpotters program. It is reasonable to assume that this group is already over-represented by those who are more likely than MGs to save their tick, so this particular result cannot can be necessarily attributed to exposure to the TickSpotters program. While the two groups experienced similar tick exposure proportions in the past year, MGs are mostly represented by retirees living in rural areas while TickSpotters respondents are represented by younger adults with families primarily living in the suburbs. Different attitudes toward and perceptions of risk about tick encounters are likely to emanate from these differences and not be related to education provided by TickSpotters. For example, a recent study in preprint demonstrated the differences in tick-bite prevention behaviors between residents living in the Lyme-endemic upper midwestern states and those in the Lyme endemic northeastern states. The researchers found that those living in rural areas the Midwest were more likely to, kill rodents on their property, spend time outdoors, and use personal protective measures than those

living in the Northeast, but that those in the Northeast used more yard protection measures (Bron et al. *in review*). It is reasonable to expect that families with young children are more concerned about potential tick bite exposure and therefore are submitting ticks for identification, as well as simply have less experience with ticks than the older population representing MGs.

The results of this study suggest that there is a group with a particular exigence to connect with tick experts, but who are still lacking in tick bite prevention behavior frequency. There was no difference in the proportion of prevention behaviors performed by respondents before and after using the TickSpotters program. Given that the vast majority of TickSpotters respondents only submitted a single tick report encounter, their exposure to the program's public health messaging is highly limited and can possibly explain the weak adherence to prevention behaviors. Evaluating the behaviors stratified by number of submissions could possibly better elucidate relationships among more frequent usage and better adherence to prevention behaviors. Future work within the TickSpotters program should incorporate conducting pre-and post-program exposure surveys with TickSpotters users to better capture how the intervention is affecting perceptions and knowledge, as well as offering contextual ways to overcome barriers to action that address fears of pesticides, e.g. effective alternatives to pyrethroid yard sprays, or instruction on the need to increase application frequency of "less toxic" repellents like oil of lemon eucalyptus. Identifying means of maintaining further engagement with TickSpotters program participants, like seasonal emails for tick check reminders, should also be an ongoing priority. Further, these results demonstrate that MGs perform tick checks, but otherwise exhibit behaviors that put them potentially at risk for illness (e.g. removing ticks with fingers, applying topical oils to remove ticks,

and lacking in knowledge about tick activity and disease transmission). Further study should examine how to utilize theory-based approaches to aid in protecting MGs from tick-borne illness.

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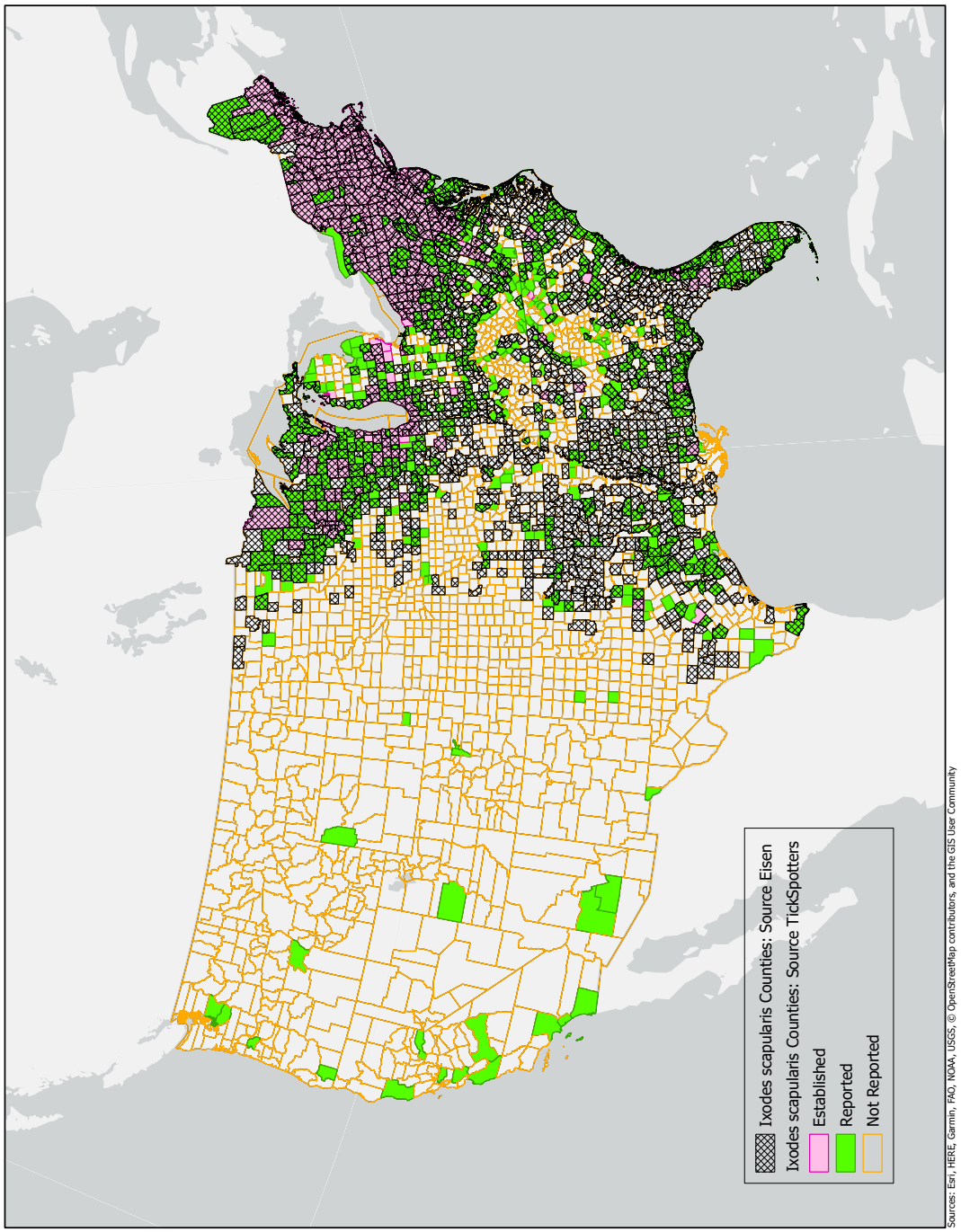
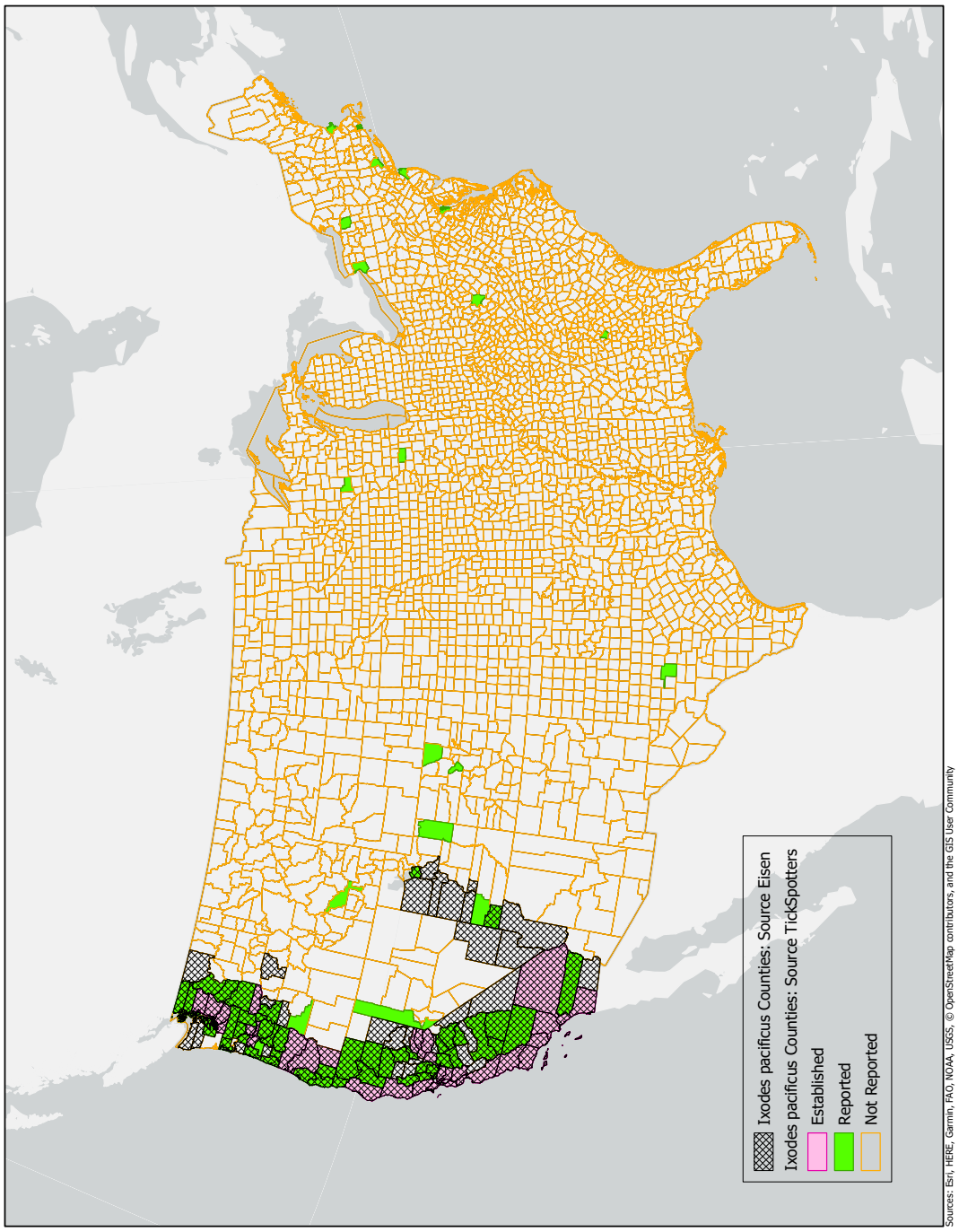
APPENDICES

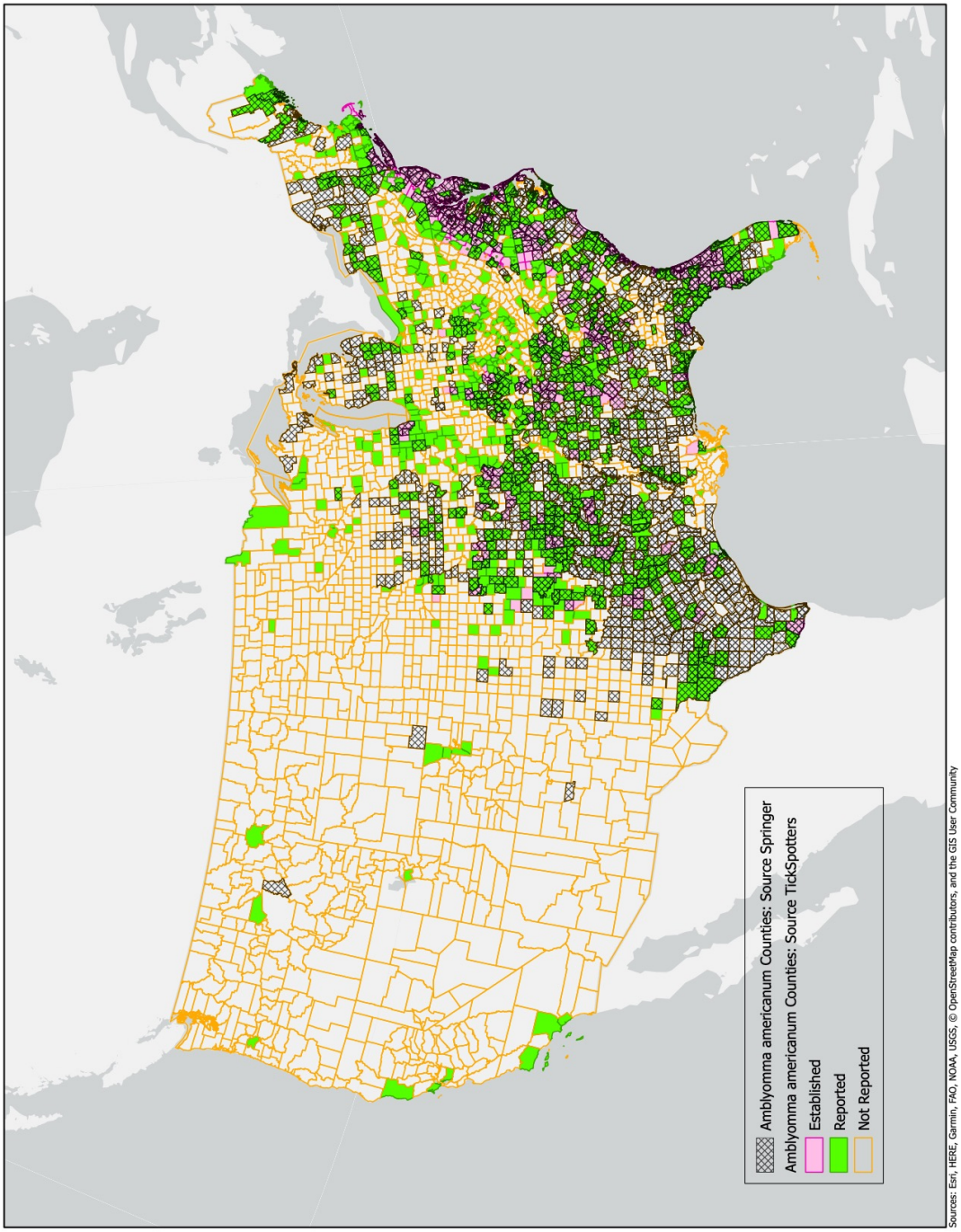
Appendix 1. County-level distribution of *Ixodes scapularis* as reported to TickSpotters (2014-2019) compared to Eisen et al. 2017. TickSpotters reported "Establishment" (pink) is defined as a county with either 2 life stages present or at least 6 individual ticks of any life stage. TickSpotters' "Reported" (green) is defined as at least one occurrence in a county of any recorded tick stage (Dennis et al. 1998). Counties with any record of *I. scapularis* as reported by Eisen et al. 2017 is denoted by the black hatch pattern.



Appendix 2. County-level distribution of *Ixodes pacificus* as reported to TickSpotters (2014-2019) compared to Eisen et al. 2017. TickSpotters reported "Establishment" (pink) is defined as a county with either 2 life stages present or at least 6 individual ticks of any life stage. TickSpotters' "Reported" (green) is defined as at least one occurrence in a county of any recorded tick stage (Dennis et al. 1998). Counties with any record of *I. pacificus* as reported by Eisen et al. 2017 is denoted by the black hatch pattern.



Appendix 3. County-level distribution of *Amblyomma americanum* as reported to TickSpotters (2014-2019) compared to Springer et al. 2014. TickSpotters reported "Establishment" (pink) is defined as a county with either 2 life stages present or at least 6 individual ticks of any life stage. TickSpotters' "Reported" (green) is defined as at least one occurrence in a county of any recorded tick stage (Dennis et al. 1998). Counties with any record of *A. americanum* as reported by Springer et al. 2014 are denoted by the black hatch pattern.



Appendix 4. Comparison of United States counties with presence of *Ixodes scapularis* as reported by Eisen et al. 2017 and the TickSpotters program (2014-2019).

FIPS	County	State	Eisen et al. 2017 County Status for *I. scapularis*	TickSpotters (2014-2019) County Status for *I. scapularis*
10003	New Castle	Delaware	Established	Established
12001	Alachua	Florida	Established	Established
12083	Marion	Florida	Established	Established
12113	Santa Rosa	Florida	Established	Established
13051	Chatham	Georgia	Established	Established
17031	Cook	Illinois	Established	Established
17097	Lake	Illinois	Established	Established
17141	Ogle	Illinois	Established	Established
17197	Will	Illinois	Established	Established
17201	Winnebago	Illinois	Established	Established
18089	Lake	Indiana	Established	Established
18127	Porter	Indiana	Established	Established
19113	Linn	Iowa	Established	Established
23001	Androscoggin	Maine	Established	Established
23005	Cumberland	Maine	Established	Established
23009	Hancock	Maine	Established	Established
23011	Kennebec	Maine	Established	Established
23013	Knox	Maine	Established	Established
23015	Lincoln	Maine	Established	Established
23017	Oxford	Maine	Established	Established
23019	Penobscot	Maine	Established	Established
23023	Sagadahoc	Maine	Established	Established
23027	Waldo	Maine	Established	Established
23029	Washington	Maine	Established	Established
23031	York	Maine	Established	Established
24003	Anne Arundel	Maryland	Established	Established
24005	Baltimore	Maryland	Established	Established
24013	Carroll	Maryland	Established	Established
24021	Frederick	Maryland	Established	Established
24025	Harford	Maryland	Established	Established
24027	Howard	Maryland	Established	Established
24031	Montgomery	Maryland	Established	Established
24043	Washington	Maryland	Established	Established
24510	Baltimore City	Maryland	Established	Established
25001	Barnstable	Massachusetts	Established	Established
25003	Berkshire	Massachusetts	Established	Established
25005	Bristol	Massachusetts	Established	Established
25007	Dukes	Massachusetts	Established	Established
25009	Essex	Massachusetts	Established	Established
25011	Franklin	Massachusetts	Established	Established
25013	Hampden	Massachusetts	Established	Established
25015	Hampshire	Massachusetts	Established	Established
25017	Middlesex	Massachusetts	Established	Established
25019	Nantucket	Massachusetts	Established	Established
25021	Norfolk	Massachusetts	Established	Established
25023	Plymouth	Massachusetts	Established	Established
25025	Suffolk	Massachusetts	Established	Established
25027	Worcester	Massachusetts	Established	Established
26021	Berrien	Michigan	Established	Established
26043	Dickinson	Michigan	Established	Established
26065	Ingham	Michigan	Established	Established
26077	Kalamazoo	Michigan	Established	Established
26089	Leelanau	Michigan	Established	Established

FIPS	County	State	Eisen et al. 2017 County Status for *I. scapularis*	TickSpotters (2014-2019) County Status for *I. scapularis*
26121	Muskegon	Michigan	Established	Established
26139	Ottawa	Michigan	Established	Established
27003	Anoka	Minnesota	Established	Established
27025	Chisago	Minnesota	Established	Established
27035	Crow Wing	Minnesota	Established	Established
27037	Dakota	Minnesota	Established	Established
27053	Hennepin	Minnesota	Established	Established
27123	Ramsey	Minnesota	Established	Established
27163	Washington	Minnesota	Established	Established
33001	Belknap	New Hampshire	Established	Established
33003	Carroll	New Hampshire	Established	Established
33005	Cheshire	New Hampshire	Established	Established
33009	Grafton	New Hampshire	Established	Established
33011	Hillsborough	New Hampshire	Established	Established
33013	Merrimack	New Hampshire	Established	Established
33015	Rockingham	New Hampshire	Established	Established
33017	Strafford	New Hampshire	Established	Established
33019	Sullivan	New Hampshire	Established	Established
34001	Atlantic	New Jersey	Established	Established
34003	Bergen	New Jersey	Established	Established
34005	Burlington	New Jersey	Established	Established
34007	Camden	New Jersey	Established	Established
34013	Essex	New Jersey	Established	Established
34015	Gloucester	New Jersey	Established	Established
34017	Hudson	New Jersey	Established	Established
34019	Hunterdon	New Jersey	Established	Established
34021	Mercer	New Jersey	Established	Established
34023	Middlesex	New Jersey	Established	Established
34025	Monmouth	New Jersey	Established	Established
34027	Morris	New Jersey	Established	Established
34029	Ocean	New Jersey	Established	Established
34031	Passaic	New Jersey	Established	Established
34035	Somerset	New Jersey	Established	Established
34037	Sussex	New Jersey	Established	Established
34039	Union	New Jersey	Established	Established
34041	Warren	New Jersey	Established	Established
36001	Albany	New York	Established	Established
36003	Allegany	New York	Established	Established
36005	Bronx	New York	Established	Established
36007	Broome	New York	Established	Established
36009	Cattaraugus	New York	Established	Established
36011	Cayuga	New York	Established	Established
36013	Chautauqua	New York	Established	Established
36015	Chemung	New York	Established	Established
36017	Chenango	New York	Established	Established
36019	Clinton	New York	Established	Established
36021	Columbia	New York	Established	Established
36025	Delaware	New York	Established	Established
36027	Dutchess	New York	Established	Established
36029	Erie	New York	Established	Established
36031	Essex	New York	Established	Established
36033	Franklin	New York	Established	Established
36035	Fulton	New York	Established	Established
36037	Genesee	New York	Established	Established
36039	Greene	New York	Established	Established
36043	Herkimer	New York	Established	Established
36045	Jefferson	New York	Established	Established
36047	Kings	New York	Established	Established

FIPS	County	State	Eisen et al. 2017 County Status for *I. scapularis*	TickSpotters (2014-2019) County Status for *I. scapularis*
36049	Lewis	New York	Established	Established
36051	Livingston	New York	Established	Established
36053	Madison	New York	Established	Established
36055	Monroe	New York	Established	Established
36059	Nassau	New York	Established	Established
36061	New York	New York	Established	Established
36065	Oneida	New York	Established	Established
36067	Onondaga	New York	Established	Established
36069	Ontario	New York	Established	Established
36071	Orange	New York	Established	Established
36075	Oswego	New York	Established	Established
36077	Otsego	New York	Established	Established
36079	Putnam	New York	Established	Established
36081	Queens	New York	Established	Established
36083	Rensselaer	New York	Established	Established
36085	Richmond	New York	Established	Established
36087	Rockland	New York	Established	Established
36091	Saratoga	New York	Established	Established
36093	Schenectady	New York	Established	Established
36095	Schoharie	New York	Established	Established
36101	Steuben	New York	Established	Established
36103	Suffolk	New York	Established	Established
36105	Sullivan	New York	Established	Established
36107	Tioga	New York	Established	Established
36109	Tompkins	New York	Established	Established
36111	Ulster	New York	Established	Established
36113	Warren	New York	Established	Established
36115	Washington	New York	Established	Established
36117	Wayne	New York	Established	Established
36119	Westchester	New York	Established	Established
36121	Wyoming	New York	Established	Established
36123	Yates	New York	Established	Established
37183	Wake	North Carolina	Established	Established
39007	Ashtabula	Ohio	Established	Established
39029	Columbiana	Ohio	Established	Established
39035	Cuyahoga	Ohio	Established	Established
39075	Holmes	Ohio	Established	Established
39085	Lake	Ohio	Established	Established
39089	Licking	Ohio	Established	Established
39103	Medina	Ohio	Established	Established
39133	Portage	Ohio	Established	Established
39151	Stark	Ohio	Established	Established
39153	Summit	Ohio	Established	Established
39155	Trumbull	Ohio	Established	Established
42001	Adams	Pennsylvania	Established	Established
42003	Allegheny	Pennsylvania	Established	Established
42005	Armstrong	Pennsylvania	Established	Established
42007	Beaver	Pennsylvania	Established	Established
42011	Berks	Pennsylvania	Established	Established
42013	Blair	Pennsylvania	Established	Established
42015	Bradford	Pennsylvania	Established	Established
42017	Bucks	Pennsylvania	Established	Established
42019	Butler	Pennsylvania	Established	Established
42021	Cambria	Pennsylvania	Established	Established
42025	Carbon	Pennsylvania	Established	Established
42027	Centre	Pennsylvania	Established	Established
42029	Chester	Pennsylvania	Established	Established
42031	Clarion	Pennsylvania	Established	Established

FIPS	County	State	Eisen et al. 2017 County Status for *I. scapularis*	TickSpotters (2014-2019) County Status for *I. scapularis*
42035	Clinton	Pennsylvania	Established	Established
42037	Columbia	Pennsylvania	Established	Established
42039	Crawford	Pennsylvania	Established	Established
42041	Cumberland	Pennsylvania	Established	Established
42043	Dauphin	Pennsylvania	Established	Established
42045	Delaware	Pennsylvania	Established	Established
42049	Erie	Pennsylvania	Established	Established
42051	Fayette	Pennsylvania	Established	Established
42055	Franklin	Pennsylvania	Established	Established
42061	Huntingdon	Pennsylvania	Established	Established
42063	Indiana	Pennsylvania	Established	Established
42069	Lackawanna	Pennsylvania	Established	Established
42071	Lancaster	Pennsylvania	Established	Established
42073	Lawrence	Pennsylvania	Established	Established
42075	Lebanon	Pennsylvania	Established	Established
42077	Lehigh	Pennsylvania	Established	Established
42079	Luzerne	Pennsylvania	Established	Established
42081	Lycoming	Pennsylvania	Established	Established
42085	Mercer	Pennsylvania	Established	Established
42089	Monroe	Pennsylvania	Established	Established
42091	Montgomery	Pennsylvania	Established	Established
42095	Northampton	Pennsylvania	Established	Established
42101	Philadelphia	Pennsylvania	Established	Established
42103	Pike	Pennsylvania	Established	Established
42105	Potter	Pennsylvania	Established	Established
42107	Schuylkill	Pennsylvania	Established	Established
42115	Susquehanna	Pennsylvania	Established	Established
42117	Tioga	Pennsylvania	Established	Established
42121	Venango	Pennsylvania	Established	Established
42123	Warren	Pennsylvania	Established	Established
42125	Washington	Pennsylvania	Established	Established
42127	Wayne	Pennsylvania	Established	Established
42129	Westmoreland	Pennsylvania	Established	Established
42131	Wyoming	Pennsylvania	Established	Established
42133	York	Pennsylvania	Established	Established
44001	Bristol	Rhode Island	Established	Established
44003	Kent	Rhode Island	Established	Established
44005	Newport	Rhode Island	Established	Established
44007	Providence	Rhode Island	Established	Established
44009	Washington	Rhode Island	Established	Established
47093	Knox	Tennessee	Established	Established
50003	Bennington	Vermont	Established	Established
50005	Caledonia	Vermont	Established	Established
50007	Chittenden	Vermont	Established	Established
50011	Franklin	Vermont	Established	Established
50017	Orange	Vermont	Established	Established
50021	Rutland	Vermont	Established	Established
50023	Washington	Vermont	Established	Established
50025	Windham	Vermont	Established	Established
50027	Windsor	Vermont	Established	Established
51003	Albemarle	Virginia	Established	Established
51015	Augusta	Virginia	Established	Established
51041	Chesterfield	Virginia	Established	Established
51059	Fairfax	Virginia	Established	Established
51061	Fauquier	Virginia	Established	Established
51107	Loudoun	Virginia	Established	Established
51121	Montgomery	Virginia	Established	Established
51153	Prince William	Virginia	Established	Established

FIPS	County	State	Eisen et al. 2017 County Status for *I. scapularis*	TickSpotters (2014-2019) County Status for *I. scapularis*
51163	Rockbridge	Virginia	Established	Established
54003	Berkeley	West Virginia	Established	Established
54033	Harrison	West Virginia	Established	Established
54039	Kanawha	West Virginia	Established	Established
54061	Monongalia	West Virginia	Established	Established
54097	Upshur	West Virginia	Established	Established
55013	Burnett	Wisconsin	Established	Established
55017	Chippewa	Wisconsin	Established	Established
55025	Dane	Wisconsin	Established	Established
55029	Door	Wisconsin	Established	Established
55035	Eau Claire	Wisconsin	Established	Established
55063	La Crosse	Wisconsin	Established	Established
55073	Marathon	Wisconsin	Established	Established
55075	Marinette	Wisconsin	Established	Established
55079	Milwaukee	Wisconsin	Established	Established
55083	Oconto	Wisconsin	Established	Established
55085	Oneida	Wisconsin	Established	Established
55097	Portage	Wisconsin	Established	Established
55101	Racine	Wisconsin	Established	Established
55105	Rock	Wisconsin	Established	Established
55111	Sauk	Wisconsin	Established	Established
55117	Sheboygan	Wisconsin	Established	Established
55125	Vilas	Wisconsin	Established	Established
55127	Walworth	Wisconsin	Established	Established
55129	Washburn	Wisconsin	Established	Established
55133	Waukesha	Wisconsin	Established	Established
09001	Fairfield	Connecticut	Established	Established
09003	Hartford	Connecticut	Established	Established
09005	Litchfield	Connecticut	Established	Established
09007	Middlesex	Connecticut	Established	Established
09009	New Haven	Connecticut	Established	Established
09011	New London	Connecticut	Established	Established
09013	Tolland	Connecticut	Established	Established
09015	Windham	Connecticut	Established	Established
01005	Barbour	Alabama	Established	No record
01007	Bibb	Alabama	Established	No record
01013	Butler	Alabama	Established	No record
01017	Chambers	Alabama	Established	No record
01023	Choctaw	Alabama	Established	No record
01025	Clarke	Alabama	Established	No record
01035	Conecuh	Alabama	Established	No record
01037	Coosa	Alabama	Established	No record
01039	Covington	Alabama	Established	No record
01051	Elmore	Alabama	Established	No record
01059	Franklin	Alabama	Established	No record
01065	Hale	Alabama	Established	No record
01067	Henry	Alabama	Established	No record
01071	Jackson	Alabama	Established	No record
01099	Monroe	Alabama	Established	No record
01107	Pickens	Alabama	Established	No record
01133	Winston	Alabama	Established	No record
12003	Baker	Florida	Established	No record
12013	Calhoun	Florida	Established	No record
12023	Columbia	Florida	Established	No record
12029	Dixie	Florida	Established	No record
12043	Glades	Florida	Established	No record
12045	Gulf	Florida	Established	No record
12047	Hamilton	Florida	Established	No record

FIPS	County	State	Eisen et al. 2017 County Status for *I. scapularis*	TickSpotters (2014-2019) County Status for *I. scapularis*
12051	Hendry	Florida	Established	No record
12055	Highlands	Florida	Established	No record
12061	Indian River	Florida	Established	No record
12063	Jackson	Florida	Established	No record
12067	Lafayette	Florida	Established	No record
12069	Lake	Florida	Established	No record
12075	Levy	Florida	Established	No record
12077	Liberty	Florida	Established	No record
12079	Madison	Florida	Established	No record
12085	Martin	Florida	Established	No record
12093	Okeechobee	Florida	Established	No record
12097	Osceola	Florida	Established	No record
12103	Pinellas	Florida	Established	No record
12119	Sumter	Florida	Established	No record
12123	Taylor	Florida	Established	No record
13023	Bleckley	Georgia	Established	No record
13025	Brantley	Georgia	Established	No record
13031	Bulloch	Georgia	Established	No record
13033	Burke	Georgia	Established	No record
13043	Candler	Georgia	Established	No record
13049	Charlton	Georgia	Established	No record
13065	Clinch	Georgia	Established	No record
13103	Effingham	Georgia	Established	No record
13107	Emanuel	Georgia	Established	No record
13131	Grady	Georgia	Established	No record
13155	Irwin	Georgia	Established	No record
13163	Jefferson	Georgia	Established	No record
13165	Jenkins	Georgia	Established	No record
13167	Johnson	Georgia	Established	No record
13175	Laurens	Georgia	Established	No record
13207	Monroe	Georgia	Established	No record
13209	Montgomery	Georgia	Established	No record
13237	Putnam	Georgia	Established	No record
13263	Talbot	Georgia	Established	No record
13271	Telfair	Georgia	Established	No record
13275	Thomas	Georgia	Established	No record
13279	Toombs	Georgia	Established	No record
13283	Treutlen	Georgia	Established	No record
13299	Ware	Georgia	Established	No record
13303	Washington	Georgia	Established	No record
17011	Bureau	Illinois	Established	No record
17023	Clark	Illinois	Established	No record
17029	Coles	Illinois	Established	No record
17039	De Witt	Illinois	Established	No record
17057	Fulton	Illinois	Established	No record
17091	Kankakee	Illinois	Established	No record
17117	Macoupin	Illinois	Established	No record
17123	Marshall	Illinois	Established	No record
17125	Mason	Illinois	Established	No record
17133	Monroe	Illinois	Established	No record
17147	Piatt	Illinois	Established	No record
17155	Putnam	Illinois	Established	No record
17169	Schuyler	Illinois	Established	No record
17173	Shelby	Illinois	Established	No record
17179	Tazewell	Illinois	Established	No record
17185	Wabash	Illinois	Established	No record
17203	Woodford	Illinois	Established	No record
18017	Cass	Indiana	Established	No record

FIPS	County	State	Eisen et al. 2017 County Status for *I. scapularis*	TickSpotters (2014-2019) County Status for *I. scapularis*
18037	Dubois	Indiana	Established	No record
18047	Franklin	Indiana	Established	No record
18049	Fulton	Indiana	Established	No record
18077	Jefferson	Indiana	Established	No record
18079	Jennings	Indiana	Established	No record
18101	Martin	Indiana	Established	No record
18107	Montgomery	Indiana	Established	No record
18109	Morgan	Indiana	Established	No record
18111	Newton	Indiana	Established	No record
18121	Parke	Indiana	Established	No record
18133	Putnam	Indiana	Established	No record
18153	Sullivan	Indiana	Established	No record
18171	Warren	Indiana	Established	No record
18181	White	Indiana	Established	No record
19057	Des Moines	Iowa	Established	No record
19097	Jackson	Iowa	Established	No record
19107	Keokuk	Iowa	Established	No record
19169	Story	Iowa	Established	No record
19187	Webster	Iowa	Established	No record
21041	Carroll	Kentucky	Established	No record
21051	Clay	Kentucky	Established	No record
21065	Estill	Kentucky	Established	No record
21093	Hardin	Kentucky	Established	No record
21109	Jackson	Kentucky	Established	No record
21121	Knox	Kentucky	Established	No record
21129	Lee	Kentucky	Established	No record
21163	Meade	Kentucky	Established	No record
21189	Owsley	Kentucky	Established	No record
21199	Pulaski	Kentucky	Established	No record
21223	Trimble	Kentucky	Established	No record
22003	Allen	Louisiana	Established	No record
22009	Avoyelles	Louisiana	Established	No record
22013	Bienville	Louisiana	Established	No record
22021	Caldwell	Louisiana	Established	No record
22029	Concordia	Louisiana	Established	No record
22043	Grant	Louisiana	Established	No record
22049	Jackson	Louisiana	Established	No record
22067	Morehouse	Louisiana	Established	No record
22069	Natchitoches	Louisiana	Established	No record
22111	Union	Louisiana	Established	No record
24019	Dorchester	Maryland	Established	No record
24039	Somerset	Maryland	Established	No record
26067	Ionia	Michigan	Established	No record
26101	Manistee	Michigan	Established	No record
26131	Ontonagon	Michigan	Established	No record
26153	Schoolcraft	Michigan	Established	No record
27021	Cass	Minnesota	Established	No record
27031	Cook	Minnesota	Established	No record
27041	Douglas	Minnesota	Established	No record
27045	Fillmore	Minnesota	Established	No record
27059	Isanti	Minnesota	Established	No record
27065	Kanabec	Minnesota	Established	No record
27067	Kandiyohi	Minnesota	Established	No record
27071	Koochiching	Minnesota	Established	No record
27087	Mahnomen	Minnesota	Established	No record
27121	Pope	Minnesota	Established	No record
27143	Sibley	Minnesota	Established	No record
27159	Wadena	Minnesota	Established	No record

FIPS	County	State	Eisen et al. 2017 County Status for *I. scapularis*	TickSpotters (2014-2019) County Status for *I. scapularis*
28011	Bolivar	Mississippi	Established	No record
28029	Copiah	Mississippi	Established	No record
28049	Hinds	Mississippi	Established	No record
28059	Jackson	Mississippi	Established	No record
28093	Marshall	Mississippi	Established	No record
28103	Noxubee	Mississippi	Established	No record
28111	Perry	Mississippi	Established	No record
28121	Rankin	Mississippi	Established	No record
28159	Winston	Mississippi	Established	No record
29001	Adair	Missouri	Established	No record
29015	Benton	Missouri	Established	No record
29017	Bollinger	Missouri	Established	No record
29027	Callaway	Missouri	Established	No record
29031	Cape Girardeau	Missouri	Established	No record
29059	Dallas	Missouri	Established	No record
29065	Dent	Missouri	Established	No record
29067	Douglas	Missouri	Established	No record
29073	Gasconade	Missouri	Established	No record
29091	Howell	Missouri	Established	No record
29097	Jasper	Missouri	Established	No record
29101	Johnson	Missouri	Established	No record
29105	Laclede	Missouri	Established	No record
29151	Osage	Missouri	Established	No record
29169	Pulaski	Missouri	Established	No record
29207	Stoddard	Missouri	Established	No record
29209	Stone	Missouri	Established	No record
29213	Taney	Missouri	Established	No record
29215	Texas	Missouri	Established	No record
29223	Wayne	Missouri	Established	No record
29225	Webster	Missouri	Established	No record
36097	Schuyler	New York	Established	No record
37001	Alamance	North Carolina	Established	No record
37013	Beaufort	North Carolina	Established	No record
37015	Bertie	North Carolina	Established	No record
37017	Bladen	North Carolina	Established	No record
37029	Camden	North Carolina	Established	No record
37031	Carteret	North Carolina	Established	No record
37041	Chowan	North Carolina	Established	No record
37047	Columbus	North Carolina	Established	No record
37049	Craven	North Carolina	Established	No record
37063	Durham	North Carolina	Established	No record
37065	Edgecombe	North Carolina	Established	No record
37073	Gates	North Carolina	Established	No record
37083	Halifax	North Carolina	Established	No record
37085	Harnett	North Carolina	Established	No record
37091	Hertford	North Carolina	Established	No record
37095	Hyde	North Carolina	Established	No record
37103	Jones	North Carolina	Established	No record
37117	Martin	North Carolina	Established	No record
37127	Nash	North Carolina	Established	No record
37137	Pamlico	North Carolina	Established	No record
37143	Perquimans	North Carolina	Established	No record
37155	Robeson	North Carolina	Established	No record
37163	Sampson	North Carolina	Established	No record
37165	Scotland	North Carolina	Established	No record
37177	Tyrrell	North Carolina	Established	No record
37185	Warren	North Carolina	Established	No record
37187	Washington	North Carolina	Established	No record

FIPS	County	State	Eisen et al. 2017 County Status for *I. scapularis*	TickSpotters (2014-2019) County Status for *I. scapularis*
38009	Bottineau	North Dakota	Established	No record
38027	Eddy	North Dakota	Established	No record
38067	Pembina	North Dakota	Established	No record
38071	Ramsey	North Dakota	Established	No record
39079	Jackson	Ohio	Established	No record
39115	Morgan	Ohio	Established	No record
39121	Noble	Ohio	Established	No record
39127	Perry	Ohio	Established	No record
39131	Pike	Ohio	Established	No record
40021	Cherokee	Oklahoma	Established	No record
40079	Le Flore	Oklahoma	Established	No record
42023	Cameron	Pennsylvania	Established	No record
42067	Juniata	Pennsylvania	Established	No record
45011	Barnwell	South Carolina	Established	No record
45023	Chester	South Carolina	Established	No record
45041	Florence	South Carolina	Established	No record
45049	Hampton	South Carolina	Established	No record
45053	Jasper	South Carolina	Established	No record
45071	Newberry	South Carolina	Established	No record
45087	Union	South Carolina	Established	No record
47003	Bedford	Tennessee	Established	No record
47013	Campbell	Tennessee	Established	No record
47031	Coffee	Tennessee	Established	No record
47047	Fayette	Tennessee	Established	No record
47051	Franklin	Tennessee	Established	No record
47087	Jackson	Tennessee	Established	No record
47099	Lawrence	Tennessee	Established	No record
47105	Loudon	Tennessee	Established	No record
47115	Marion	Tennessee	Established	No record
47117	Marshall	Tennessee	Established	No record
48005	Angelina	Texas	Established	No record
48007	Aransas	Texas	Established	No record
48039	Brazoria	Texas	Established	No record
48067	Cass	Texas	Established	No record
48161	Freestone	Texas	Established	No record
48213	Henderson	Texas	Established	No record
48241	Jasper	Texas	Established	No record
48285	Lavaca	Texas	Established	No record
48289	Leon	Texas	Established	No record
48315	Marion	Texas	Established	No record
48367	Parker	Texas	Established	No record
48373	Polk	Texas	Established	No record
48385	Real	Texas	Established	No record
48455	Trinity	Texas	Established	No record
48457	Tyler	Texas	Established	No record
48473	Waller	Texas	Established	No record
48499	Wood	Texas	Established	No record
05003	Ashley	Arkansas	Established	No record
05005	Baxter	Arkansas	Established	No record
05019	Clark	Arkansas	Established	No record
05023	Cleburne	Arkansas	Established	No record
05033	Crawford	Arkansas	Established	No record
05045	Faulkner	Arkansas	Established	No record
05047	Franklin	Arkansas	Established	No record
05049	Fulton	Arkansas	Established	No record
05051	Garland	Arkansas	Established	No record
05053	Grant	Arkansas	Established	No record
05057	Hempstead	Arkansas	Established	No record

FIPS	County	State	Eisen et al. 2017 County Status for *I. scapularis*	TickSpotters (2014-2019) County Status for *I. scapularis*
05075	Lawrence	Arkansas	Established	No record
05087	Madison	Arkansas	Established	No record
05089	Marion	Arkansas	Established	No record
51011	Appomattox	Virginia	Established	No record
51021	Bland	Virginia	Established	No record
51029	Buckingham	Virginia	Established	No record
51045	Craig	Virginia	Established	No record
51075	Goochland	Virginia	Established	No record
51099	King George	Virginia	Established	No record
05111	Poinsett	Arkansas	Established	No record
51119	Middlesex	Virginia	Established	No record
51131	Northampton	Virginia	Established	No record
05115	Pope	Arkansas	Established	No record
05117	Prairie	Arkansas	Established	No record
51175	Southampton	Virginia	Established	No record
51193	Westmoreland	Virginia	Established	No record
05129	Searcy	Arkansas	Established	No record
05133	Sevier	Arkansas	Established	No record
05137	Stone	Arkansas	Established	No record
05143	Washington	Arkansas	Established	No record
51800	Suffolk	Virginia	Established	No record
54001	Barbour	West Virginia	Established	No record
54021	Gilmer	West Virginia	Established	No record
54025	Greenbrier	West Virginia	Established	No record
54031	Hardy	West Virginia	Established	No record
54089	Summers	West Virginia	Established	No record
54105	Wirt	West Virginia	Established	No record
55003	Ashland	Wisconsin	Established	No record
55011	Buffalo	Wisconsin	Established	No record
55019	Clark	Wisconsin	Established	No record
55041	Forest	Wisconsin	Established	No record
55043	Grant	Wisconsin	Established	No record
55047	Green Lake	Wisconsin	Established	No record
10001	Kent	Delaware	Established	Reported
10005	Sussex	Delaware	Established	Reported
01001	Autauga	Alabama	Established	Reported
01011	Bullock	Alabama	Established	Reported
01033	Colbert	Alabama	Established	Reported
01053	Escambia	Alabama	Established	Reported
01081	Lee	Alabama	Established	Reported
01097	Mobile	Alabama	Established	Reported
01113	Russell	Alabama	Established	Reported
01123	Tallapoosa	Alabama	Established	Reported
12005	Bay	Florida	Established	Reported
12009	Brevard	Florida	Established	Reported
12019	Clay	Florida	Established	Reported
12021	Collier	Florida	Established	Reported
12033	Escambia	Florida	Established	Reported
12035	Flagler	Florida	Established	Reported
12037	Franklin	Florida	Established	Reported
12039	Gadsden	Florida	Established	Reported
12053	Hernando	Florida	Established	Reported
12057	Hillsborough	Florida	Established	Reported
12065	Jefferson	Florida	Established	Reported
12071	Lee	Florida	Established	Reported
12073	Leon	Florida	Established	Reported
12087	Monroe	Florida	Established	Reported
12089	Nassau	Florida	Established	Reported

FIPS	County	State	Eisen et al. 2017 County Status for *I. scapularis*	TickSpotters (2014-2019) County Status for *I. scapularis*
12095	Orange	Florida	Established	Reported
12099	Palm Beach	Florida	Established	Reported
12105	Polk	Florida	Established	Reported
12107	Putnam	Florida	Established	Reported
12115	Sarasota	Florida	Established	Reported
12117	Seminole	Florida	Established	Reported
12127	Volusia	Florida	Established	Reported
12129	Wakulla	Florida	Established	Reported
12131	Walton	Florida	Established	Reported
13095	Dougherty	Georgia	Established	Reported
13109	Evans	Georgia	Established	Reported
13127	Glynn	Georgia	Established	Reported
13153	Houston	Georgia	Established	Reported
13159	Jasper	Georgia	Established	Reported
13179	Liberty	Georgia	Established	Reported
13185	Lowndes	Georgia	Established	Reported
17015	Carroll	Illinois	Established	Reported
17019	Champaign	Illinois	Established	Reported
17063	Grundy	Illinois	Established	Reported
17073	Henry	Illinois	Established	Reported
17085	Jo Daviess	Illinois	Established	Reported
17103	Lee	Illinois	Established	Reported
17143	Peoria	Illinois	Established	Reported
17161	Rock Island	Illinois	Established	Reported
17183	Vermilion	Illinois	Established	Reported
18005	Bartholomew	Indiana	Established	Reported
18021	Clay	Indiana	Established	Reported
18073	Jasper	Indiana	Established	Reported
18085	Kosciusko	Indiana	Established	Reported
18105	Monroe	Indiana	Established	Reported
18119	Owen	Indiana	Established	Reported
18131	Pulaski	Indiana	Established	Reported
18149	Starke	Indiana	Established	Reported
18157	Tippecanoe	Indiana	Established	Reported
18167	Vigo	Indiana	Established	Reported
19017	Bremer	Iowa	Established	Reported
19033	Cerro Gordo	Iowa	Established	Reported
19103	Johnson	Iowa	Established	Reported
19139	Muscatine	Iowa	Established	Reported
19153	Polk	Iowa	Established	Reported
19163	Scott	Iowa	Established	Reported
19191	Winneshiek	Iowa	Established	Reported
20045	Douglas	Kansas	Established	Reported
21015	Boone	Kentucky	Established	Reported
21067	Fayette	Kentucky	Established	Reported
22061	Lincoln	Louisiana	Established	Reported
22115	Vernon	Louisiana	Established	Reported
23003	Aroostook	Maine	Established	Reported
23007	Franklin	Maine	Established	Reported
23021	Piscataquis	Maine	Established	Reported
23025	Somerset	Maine	Established	Reported
24009	Calvert	Maryland	Established	Reported
24011	Caroline	Maryland	Established	Reported
24015	Cecil	Maryland	Established	Reported
24017	Charles	Maryland	Established	Reported
24029	Kent	Maryland	Established	Reported
24041	Talbot	Maryland	Established	Reported
24045	Wicomico	Maryland	Established	Reported

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24047	Worcester	Maryland	Established	Reported
26005	Allegan	Michigan	Established	Reported
26015	Barry	Michigan	Established	Reported
26019	Benzie	Michigan	Established	Reported
26027	Cass	Michigan	Established	Reported
26029	Charlevoix	Michigan	Established	Reported
26033	Chippewa	Michigan	Established	Reported
26041	Delta	Michigan	Established	Reported
26053	Gogebic	Michigan	Established	Reported
26105	Mason	Michigan	Established	Reported
26109	Menominee	Michigan	Established	Reported
26127	Oceana	Michigan	Established	Reported
26159	Van Buren	Michigan	Established	Reported
27001	Aitkin	Minnesota	Established	Reported
27005	Becker	Minnesota	Established	Reported
27007	Beltrami	Minnesota	Established	Reported
27009	Benton	Minnesota	Established	Reported
27017	Carlton	Minnesota	Established	Reported
27019	Carver	Minnesota	Established	Reported
27029	Clearwater	Minnesota	Established	Reported
27049	Goodhue	Minnesota	Established	Reported
27055	Houston	Minnesota	Established	Reported
27057	Hubbard	Minnesota	Established	Reported
27061	Itasca	Minnesota	Established	Reported
27075	Lake	Minnesota	Established	Reported
27095	Mille Lacs	Minnesota	Established	Reported
27097	Morrison	Minnesota	Established	Reported
27109	Olmsted	Minnesota	Established	Reported
27111	Otter Tail	Minnesota	Established	Reported
27115	Pine	Minnesota	Established	Reported
27139	Scott	Minnesota	Established	Reported
27141	Sherburne	Minnesota	Established	Reported
27145	Stearns	Minnesota	Established	Reported
27153	Todd	Minnesota	Established	Reported
27157	Wabasha	Minnesota	Established	Reported
27169	Winona	Minnesota	Established	Reported
27171	Wright	Minnesota	Established	Reported
28105	Oktibbeha	Mississippi	Established	Reported
28123	Scott	Mississippi	Established	Reported
29077	Greene	Missouri	Established	Reported
34009	Cape May	New Jersey	Established	Reported
34011	Cumberland	New Jersey	Established	Reported
34033	Salem	New Jersey	Established	Reported
36023	Cortland	New York	Established	Reported
36041	Hamilton	New York	Established	Reported
36057	Montgomery	New York	Established	Reported
36063	Niagara	New York	Established	Reported
36099	Seneca	New York	Established	Reported
37019	Brunswick	North Carolina	Established	Reported
37037	Chatham	North Carolina	Established	Reported
37051	Cumberland	North Carolina	Established	Reported
37055	Dare	North Carolina	Established	Reported
37061	Duplin	North Carolina	Established	Reported
37079	Greene	North Carolina	Established	Reported
37093	Hoke	North Carolina	Established	Reported
37101	Johnston	North Carolina	Established	Reported
37129	New Hanover	North Carolina	Established	Reported
37133	Onslow	North Carolina	Established	Reported

FIPS	County	State	Eisen et al. 2017 County Status for *I. scapularis*	TickSpotters (2014-2019) County Status for *I. scapularis*
37135	Orange	North Carolina	Established	Reported
37141	Pender	North Carolina	Established	Reported
37159	Rowan	North Carolina	Established	Reported
37169	Stokes	North Carolina	Established	Reported
37191	Wayne	North Carolina	Established	Reported
38035	Grand Forks	North Dakota	Established	Reported
39001	Adams	Ohio	Established	Reported
39013	Belmont	Ohio	Established	Reported
39019	Carroll	Ohio	Established	Reported
39031	Coshocton	Ohio	Established	Reported
39053	Gallia	Ohio	Established	Reported
39059	Guernsey	Ohio	Established	Reported
39061	Hamilton	Ohio	Established	Reported
39067	Harrison	Ohio	Established	Reported
39073	Hocking	Ohio	Established	Reported
39081	Jefferson	Ohio	Established	Reported
39083	Knox	Ohio	Established	Reported
39087	Lawrence	Ohio	Established	Reported
39111	Monroe	Ohio	Established	Reported
39119	Muskingum	Ohio	Established	Reported
39139	Richland	Ohio	Established	Reported
39141	Ross	Ohio	Established	Reported
39169	Wayne	Ohio	Established	Reported
42009	Bedford	Pennsylvania	Established	Reported
42033	Clearfield	Pennsylvania	Established	Reported
42047	Elk	Pennsylvania	Established	Reported
42053	Forest	Pennsylvania	Established	Reported
42057	Fulton	Pennsylvania	Established	Reported
42059	Greene	Pennsylvania	Established	Reported
42065	Jefferson	Pennsylvania	Established	Reported
42087	Mifflin	Pennsylvania	Established	Reported
42093	Montour	Pennsylvania	Established	Reported
42097	Northumberland	Pennsylvania	Established	Reported
42099	Perry	Pennsylvania	Established	Reported
42109	Snyder	Pennsylvania	Established	Reported
42111	Somerset	Pennsylvania	Established	Reported
42113	Sullivan	Pennsylvania	Established	Reported
42119	Union	Pennsylvania	Established	Reported
45003	Aiken	South Carolina	Established	Reported
45013	Beaufort	South Carolina	Established	Reported
45015	Berkeley	South Carolina	Established	Reported
45019	Charleston	South Carolina	Established	Reported
45037	Edgefield	South Carolina	Established	Reported
45043	Georgetown	South Carolina	Established	Reported
47001	Anderson	Tennessee	Established	Reported
47065	Hamilton	Tennessee	Established	Reported
47143	Rhea	Tennessee	Established	Reported
47157	Shelby	Tennessee	Established	Reported
48001	Anderson	Texas	Established	Reported
48027	Bell	Texas	Established	Reported
48029	Bexar	Texas	Established	Reported
48041	Brazos	Texas	Established	Reported
48073	Cherokee	Texas	Established	Reported
48201	Harris	Texas	Established	Reported
48339	Montgomery	Texas	Established	Reported
48347	Nacogdoches	Texas	Established	Reported
48423	Smith	Texas	Established	Reported
50013	Grand Isle	Vermont	Established	Reported

FIPS	County	State	Eisen et al. 2017 County Status for *I. scapularis*	TickSpotters (2014-2019) County Status for *I. scapularis*
05007	Benton	Arkansas	Established	Reported
05009	Boone	Arkansas	Established	Reported
51019	Bedford	Virginia	Established	Reported
51033	Caroline	Virginia	Established	Reported
51063	Floyd	Virginia	Established	Reported
51065	Fluvanna	Virginia	Established	Reported
51067	Franklin	Virginia	Established	Reported
51069	Frederick	Virginia	Established	Reported
51071	Giles	Virginia	Established	Reported
51095	James City	Virginia	Established	Reported
51125	Nelson	Virginia	Established	Reported
51127	New Kent	Virginia	Established	Reported
05113	Polk	Arkansas	Established	Reported
51145	Powhatan	Virginia	Established	Reported
51155	Pulaski	Virginia	Established	Reported
51161	Roanoke	Virginia	Established	Reported
51179	Stafford	Virginia	Established	Reported
51187	Warren	Virginia	Established	Reported
51199	York	Virginia	Established	Reported
05125	Saline	Arkansas	Established	Reported
05131	Sebastian	Arkansas	Established	Reported
05139	Union	Arkansas	Established	Reported
51650	Hampton	Virginia	Established	Reported
51700	Newport News	Virginia	Established	Reported
51810	Virginia Beach	Virginia	Established	Reported
54007	Braxton	West Virginia	Established	Reported
54009	Brooke	West Virginia	Established	Reported
54029	Hancock	West Virginia	Established	Reported
54037	Jefferson	West Virginia	Established	Reported
54041	Lewis	West Virginia	Established	Reported
54049	Marion	West Virginia	Established	Reported
54055	Mercer	West Virginia	Established	Reported
54063	Monroe	West Virginia	Established	Reported
54077	Preston	West Virginia	Established	Reported
54081	Raleigh	West Virginia	Established	Reported
54091	Taylor	West Virginia	Established	Reported
54103	Wetzel	West Virginia	Established	Reported
55001	Adams	Wisconsin	Established	Reported
55005	Barron	Wisconsin	Established	Reported
55007	Bayfield	Wisconsin	Established	Reported
55009	Brown	Wisconsin	Established	Reported
55021	Columbia	Wisconsin	Established	Reported
55023	Crawford	Wisconsin	Established	Reported
55031	Douglas	Wisconsin	Established	Reported
55033	Dunn	Wisconsin	Established	Reported
55045	Green	Wisconsin	Established	Reported
55049	Iowa	Wisconsin	Established	Reported
55053	Jackson	Wisconsin	Established	Reported
55055	Jefferson	Wisconsin	Established	Reported
55057	Juneau	Wisconsin	Established	Reported
55067	Langlade	Wisconsin	Established	Reported
55069	Lincoln	Wisconsin	Established	Reported
55078	Menominee	Wisconsin	Established	Reported
55081	Monroe	Wisconsin	Established	Reported
55099	Price	Wisconsin	Established	Reported
55103	Richland	Wisconsin	Established	Reported
55107	Rusk	Wisconsin	Established	Reported
55113	Sawyer	Wisconsin	Established	Reported

FIPS	County	State	Eisen et al. 2017 County Status for *I. scapularis*	TickSpotters (2014-2019) County Status for *I. scapularis*
55119	Taylor	Wisconsin	Established	Reported
55121	Trempealeau	Wisconsin	Established	Reported
55135	Waupaca	Wisconsin	Established	Reported
11001	Washington	District Of Columbia	No record	Established
17043	Du Page	Illinois	No record	Established
17089	Kane	Illinois	No record	Established
17111	Mchenry	Illinois	No record	Established
17113	Mclean	Illinois	No record	Established
18091	La Porte	Indiana	No record	Established
18097	Marion	Indiana	No record	Established
18141	St Joseph	Indiana	No record	Established
22103	St Tammany	Louisiana	No record	Established
24033	Prince Georges	Maryland	No record	Established
26025	Calhoun	Michigan	No record	Established
26055	Grand Traverse	Michigan	No record	Established
26099	Macomb	Michigan	No record	Established
26161	Washtenaw	Michigan	No record	Established
26163	Wayne	Michigan	No record	Established
27137	St Louis	Minnesota	No record	Established
36089	St Lawrence	New York	No record	Established
37021	Buncombe	North Carolina	No record	Established
37189	Watauga	North Carolina	No record	Established
39093	Lorain	Ohio	No record	Established
42083	Mckean	Pennsylvania	No record	Established
45063	Lexington	South Carolina	No record	Established
48453	Travis	Texas	No record	Established
51139	Page	Virginia	No record	Established
55109	St Croix	Wisconsin	No record	Established
55131	Washington	Wisconsin	No record	Established
01015	Calhoun	Alabama	No record	Reported
01117	Shelby	Alabama	No record	Reported
01127	Walker	Alabama	No record	Reported
12091	Okaloosa:main	Florida	No record	Reported
12091	Okaloosa:main	Florida	No record	Reported
12091	Okaloosa:spit	Florida	No record	Reported
12091	Okaloosa:spit	Florida	No record	Reported
12109	St Johns	Florida	No record	Reported
13045	Carroll	Georgia	No record	Reported
13055	Chattooga	Georgia	No record	Reported
13083	Dade	Georgia	No record	Reported
13089	De Kalb	Georgia	No record	Reported
13113	Fayette	Georgia	No record	Reported
13121	Fulton	Georgia	No record	Reported
13139	Hall	Georgia	No record	Reported
13151	Henry	Georgia	No record	Reported
13219	Oconee	Georgia	No record	Reported
13261	Sumter	Georgia	No record	Reported
13295	Walker	Georgia	No record	Reported
13297	Walton	Georgia	No record	Reported
17037	De Kalb	Illinois	No record	Reported
17093	Kendall	Illinois	No record	Reported
17099	La Salle	Illinois	No record	Reported
17195	Whiteside	Illinois	No record	Reported
18003	Allen	Indiana	No record	Reported
18031	Decatur	Indiana	No record	Reported
18033	De Kalb	Indiana	No record	Reported
18035	Delaware	Indiana	No record	Reported
18041	Fayette	Indiana	No record	Reported

FIPS	County	State	Eisen et al. 2017 County Status for *I. scapularis*	TickSpotters (2014-2019) County Status for *I. scapularis*
18051	Gibson	Indiana	No record	Reported
18061	Harrison	Indiana	No record	Reported
18087	Lagrange	Indiana	No record	Reported
18147	Spencer	Indiana	No record	Reported
19005	Allamakee	Iowa	No record	Reported
19013	Black Hawk	Iowa	No record	Reported
19015	Boone	Iowa	No record	Reported
19111	Lee	Iowa	No record	Reported
19155	Pottawattamie	Iowa	No record	Reported
19181	Warren	Iowa	No record	Reported
21019	Boyd	Kentucky	No record	Reported
21027	Breckinridge	Kentucky	No record	Reported
21075	Fulton	Kentucky	No record	Reported
21079	Garrard	Kentucky	No record	Reported
21081	Grant	Kentucky	No record	Reported
21095	Harlan	Kentucky	No record	Reported
21101	Henderson	Kentucky	No record	Reported
21103	Henry	Kentucky	No record	Reported
21111	Jefferson	Kentucky	No record	Reported
21125	Laurel	Kentucky	No record	Reported
21151	Madison	Kentucky	No record	Reported
21197	Powell	Kentucky	No record	Reported
21203	Rockcastle	Kentucky	No record	Reported
21209	Scott	Kentucky	No record	Reported
21231	Wayne	Kentucky	No record	Reported
22059	La Salle	Louisiana	No record	Reported
22071	Orleans	Louisiana	No record	Reported
24035	Queen Annes	Maryland	No record	Reported
24037	St Marys	Maryland	No record	Reported
26001	Alcona	Michigan	No record	Reported
26009	Antrim	Michigan	No record	Reported
26017	Bay	Michigan	No record	Reported
26031	Cheboygan	Michigan	No record	Reported
26045	Eaton	Michigan	No record	Reported
26063	Huron	Michigan	No record	Reported
26073	Isabella	Michigan	No record	Reported
26079	Kalkaska	Michigan	No record	Reported
26123	Newaygo	Michigan	No record	Reported
26133	Osceola	Michigan	No record	Reported
26141	Presque Isle	Michigan	No record	Reported
26145	Saginaw	Michigan	No record	Reported
26149	St Joseph	Michigan	No record	Reported
26151	Sanilac	Michigan	No record	Reported
26155	Shiawassee	Michigan	No record	Reported
26157	Tuscola	Michigan	No record	Reported
27013	Blue Earth	Minnesota	No record	Reported
27027	Clay	Minnesota	No record	Reported
27051	Grant	Minnesota	No record	Reported
27119	Polk	Minnesota	No record	Reported
28033	De Soto	Mississippi	No record	Reported
29009	Barry	Missouri	No record	Reported
29023	Butler	Missouri	No record	Reported
29051	Cole	Missouri	No record	Reported
29071	Franklin	Missouri	No record	Reported
29095	Jackson	Missouri	No record	Reported
29109	Lawrence	Missouri	No record	Reported
29187	St Francois	Missouri	No record	Reported
29189	St Louis	Missouri	No record	Reported

FIPS	County	State	Eisen et al. 2017 County Status for *I. scapularis*	TickSpotters (2014-2019) County Status for *I. scapularis*
29221	Washington	Missouri	No record	Reported
31055	Douglas	Nebraska	No record	Reported
31153	Sarpy	Nebraska	No record	Reported
31157	Scotts Bluff	Nebraska	No record	Reported
37005	Alleghany	North Carolina	No record	Reported
37009	Ashe	North Carolina	No record	Reported
37011	Avery	North Carolina	No record	Reported
37023	Burke	North Carolina	No record	Reported
37057	Davidson	North Carolina	No record	Reported
37059	Davie	North Carolina	No record	Reported
37071	Gaston	North Carolina	No record	Reported
37089	Henderson	North Carolina	No record	Reported
37097	Iredell	North Carolina	No record	Reported
37099	Jackson	North Carolina	No record	Reported
37115	Madison	North Carolina	No record	Reported
37121	Mitchell	North Carolina	No record	Reported
37193	Wilkes	North Carolina	No record	Reported
37195	Wilson	North Carolina	No record	Reported
37199	Yancey	North Carolina	No record	Reported
38103	Wells	North Dakota	No record	Reported
39039	Defiance	Ohio	No record	Reported
39051	Fulton	Ohio	No record	Reported
39063	Hancock	Ohio	No record	Reported
39065	Hardin	Ohio	No record	Reported
39077	Huron	Ohio	No record	Reported
39107	Mercer	Ohio	No record	Reported
39109	Miami	Ohio	No record	Reported
39149	Shelby	Ohio	No record	Reported
40083	Logan	Oklahoma	No record	Reported
40103	Noble	Oklahoma	No record	Reported
45065	Mccormick	South Carolina	No record	Reported
47005	Benton	Tennessee	No record	Reported
47009	Blount	Tennessee	No record	Reported
47011	Bradley	Tennessee	No record	Reported
47019	Carter	Tennessee	No record	Reported
47063	Hamblen	Tennessee	No record	Reported
47073	Hawkins	Tennessee	No record	Reported
47089	Jefferson	Tennessee	No record	Reported
47111	Macon	Tennessee	No record	Reported
47121	Meigs	Tennessee	No record	Reported
47141	Putnam	Tennessee	No record	Reported
47173	Union	Tennessee	No record	Reported
47183	Weakley	Tennessee	No record	Reported
48063	Camp	Texas	No record	Reported
48071	Chambers	Texas	No record	Reported
48085	Collin	Texas	No record	Reported
48121	Denton	Texas	No record	Reported
48141	El Paso	Texas	No record	Reported
48199	Hardin	Texas	No record	Reported
48221	Hood	Texas	No record	Reported
48251	Johnson	Texas	No record	Reported
48259	Kendall	Texas	No record	Reported
48303	Lubbock	Texas	No record	Reported
48309	Mclennan	Texas	No record	Reported
48311	Mcmullen	Texas	No record	Reported
48365	Panola	Texas	No record	Reported
48381	Randall	Texas	No record	Reported
48407	San Jacinto	Texas	No record	Reported

FIPS	County	State	Eisen et al. 2017 County Status for *I. scapularis*	TickSpotters (2014-2019) County Status for *I. scapularis*
48479	Webb	Texas	No record	Reported
48491	Williamson	Texas	No record	Reported
05035	Crittenden	Arkansas	No record	Reported
05037	Cross	Arkansas	No record	Reported
51023	Botetourt	Virginia	No record	Reported
51031	Campbell	Virginia	No record	Reported
51035	Carroll	Virginia	No record	Reported
51043	Clarke	Virginia	No record	Reported
51077	Grayson	Virginia	No record	Reported
51091	Highland	Virginia	No record	Reported
51105	Lee	Virginia	No record	Reported
51113	Madison	Virginia	No record	Reported
51137	Orange	Virginia	No record	Reported
51143	Pittsylvania	Virginia	No record	Reported
51169	Scott	Virginia	No record	Reported
51185	Tazewell	Virginia	No record	Reported
51197	Wythe	Virginia	No record	Reported
05145	White	Arkansas	No record	Reported
54013	Calhoun	West Virginia	No record	Reported
54059	Mingo	West Virginia	No record	Reported
54067	Nicholas	West Virginia	No record	Reported
54073	Pleasants	West Virginia	No record	Reported
54099	Wayne	West Virginia	No record	Reported
55015	Calumet	Wisconsin	No record	Reported
55039	Fond Du Lac	Wisconsin	No record	Reported
55061	Kewaunee	Wisconsin	No record	Reported
55077	Marquette	Wisconsin	No record	Reported
01089	Madison	Alabama	Reported	Established
12031	Duval	Florida	Reported	Established
24001	Allegany	Maryland	Reported	Established
26049	Genesee	Michigan	Reported	Established
26081	Kent	Michigan	Reported	Established
26093	Livingston	Michigan	Reported	Established
26125	Oakland	Michigan	Reported	Established
37081	Guilford	North Carolina	Reported	Established
39049	Franklin	Ohio	Reported	Established
39055	Geauga	Ohio	Reported	Established
39095	Lucas	Ohio	Reported	Established
39099	Mahoning	Ohio	Reported	Established
39157	Tuscarawas	Ohio	Reported	Established
47037	Davidson	Tennessee	Reported	Established
48439	Tarrant	Texas	Reported	Established
50015	Lamoille	Vermont	Reported	Established
51013	Arlington	Virginia	Reported	Established
51087	Henrico	Virginia	Reported	Established
51165	Rockingham	Virginia	Reported	Established
54107	Wood	West Virginia	Reported	Established
55089	Ozaukee	Wisconsin	Reported	Established
55095	Polk	Wisconsin	Reported	Established
55141	Wood	Wisconsin	Reported	Established
01021	Chilton	Alabama	Reported	No record
01027	Clay	Alabama	Reported	No record
01029	Cleburne	Alabama	Reported	No record
01041	Crenshaw	Alabama	Reported	No record
01061	Geneva	Alabama	Reported	No record
01079	Lawrence	Alabama	Reported	No record
01085	Lowndes	Alabama	Reported	No record
01091	Marengo	Alabama	Reported	No record

FIPS	County	State	Eisen et al. 2017 County Status for *I. scapularis*	TickSpotters (2014-2019) County Status for *I. scapularis*
01111	Randolph	Alabama	Reported	No record
01119	Sumter	Alabama	Reported	No record
01121	Talladega	Alabama	Reported	No record
01129	Washington	Alabama	Reported	No record
01131	Wilcox	Alabama	Reported	No record
12007	Bradford	Florida	Reported	No record
12015	Charlotte	Florida	Reported	No record
12017	Citrus	Florida	Reported	No record
12041	Gilchrist	Florida	Reported	No record
12049	Hardee	Florida	Reported	No record
12059	Holmes	Florida	Reported	No record
12121	Suwannee	Florida	Reported	No record
12125	Union	Florida	Reported	No record
13001	Appling	Georgia	Reported	No record
13003	Atkinson	Georgia	Reported	No record
13005	Bacon	Georgia	Reported	No record
13007	Baker	Georgia	Reported	No record
13037	Calhoun	Georgia	Reported	No record
13069	Coffee	Georgia	Reported	No record
13075	Cook	Georgia	Reported	No record
13081	Crisp	Georgia	Reported	No record
13087	Decatur	Georgia	Reported	No record
13101	Echols	Georgia	Reported	No record
13141	Hancock	Georgia	Reported	No record
13161	Jeff Davis	Georgia	Reported	No record
13169	Jones	Georgia	Reported	No record
13183	Long	Georgia	Reported	No record
13211	Morgan	Georgia	Reported	No record
13229	Pierce	Georgia	Reported	No record
13235	Pulaski	Georgia	Reported	No record
13265	Taliaferro	Georgia	Reported	No record
13267	Tattnall	Georgia	Reported	No record
13273	Terrell	Georgia	Reported	No record
13277	Tift	Georgia	Reported	No record
13289	Twiggs	Georgia	Reported	No record
13305	Wayne	Georgia	Reported	No record
13317	Wilkes	Georgia	Reported	No record
13319	Wilkinson	Georgia	Reported	No record
17009	Brown	Illinois	Reported	No record
17017	Cass	Illinois	Reported	No record
17033	Crawford	Illinois	Reported	No record
17035	Cumberland	Illinois	Reported	No record
17045	Edgar	Illinois	Reported	No record
17051	Fayette	Illinois	Reported	No record
17055	Franklin	Illinois	Reported	No record
17059	Gallatin	Illinois	Reported	No record
17075	Iroquois	Illinois	Reported	No record
17077	Jackson	Illinois	Reported	No record
17101	Lawrence	Illinois	Reported	No record
17119	Madison	Illinois	Reported	No record
17129	Menard	Illinois	Reported	No record
17131	Mercer	Illinois	Reported	No record
17135	Montgomery	Illinois	Reported	No record
17137	Morgan	Illinois	Reported	No record
17145	Perry	Illinois	Reported	No record
17151	Pope	Illinois	Reported	No record
17157	Randolph	Illinois	Reported	No record
17165	Saline	Illinois	Reported	No record

FIPS	County	State	Eisen et al. 2017 County Status for *I. scapularis*	TickSpotters (2014-2019) County Status for *I. scapularis*
17167	Sangamon	Illinois	Reported	No record
17171	Scott	Illinois	Reported	No record
17181	Union	Illinois	Reported	No record
17199	Williamson	Illinois	Reported	No record
18007	Benton	Indiana	Reported	No record
18011	Boone	Indiana	Reported	No record
18015	Carroll	Indiana	Reported	No record
18019	Clark	Indiana	Reported	No record
18027	Daviess	Indiana	Reported	No record
18045	Fountain	Indiana	Reported	No record
18053	Grant	Indiana	Reported	No record
18057	Hamilton	Indiana	Reported	No record
18069	Huntington	Indiana	Reported	No record
18081	Johnson	Indiana	Reported	No record
18083	Knox	Indiana	Reported	No record
18093	Lawrence	Indiana	Reported	No record
18095	Madison	Indiana	Reported	No record
18125	Pike	Indiana	Reported	No record
18129	Posey	Indiana	Reported	No record
18135	Randolph	Indiana	Reported	No record
18137	Ripley	Indiana	Reported	No record
18145	Shelby	Indiana	Reported	No record
18161	Union	Indiana	Reported	No record
18165	Vermillion	Indiana	Reported	No record
18169	Wabash	Indiana	Reported	No record
18173	Warrick	Indiana	Reported	No record
18175	Washington	Indiana	Reported	No record
18183	Whitley	Indiana	Reported	No record
19021	Buena Vista	Iowa	Reported	No record
19025	Calhoun	Iowa	Reported	No record
19031	Cedar	Iowa	Reported	No record
19043	Clayton	Iowa	Reported	No record
19045	Clinton	Iowa	Reported	No record
19047	Crawford	Iowa	Reported	No record
19055	Delaware	Iowa	Reported	No record
19065	Fayette	Iowa	Reported	No record
19067	Floyd	Iowa	Reported	No record
19073	Greene	Iowa	Reported	No record
19077	Guthrie	Iowa	Reported	No record
19081	Hancock	Iowa	Reported	No record
19099	Jasper	Iowa	Reported	No record
19109	Kossuth	Iowa	Reported	No record
19127	Marshall	Iowa	Reported	No record
19147	Palo Alto	Iowa	Reported	No record
19171	Tama	Iowa	Reported	No record
19189	Winnebago	Iowa	Reported	No record
19193	Woodbury	Iowa	Reported	No record
20011	Bourbon	Kansas	Reported	No record
20019	Chautauqua	Kansas	Reported	No record
20021	Cherokee	Kansas	Reported	No record
20031	Coffey	Kansas	Reported	No record
20035	Cowley	Kansas	Reported	No record
20037	Crawford	Kansas	Reported	No record
20087	Jefferson	Kansas	Reported	No record
20099	Labette	Kansas	Reported	No record
20107	Linn	Kansas	Reported	No record
20121	Miami	Kansas	Reported	No record
20125	Montgomery	Kansas	Reported	No record

FIPS	County	State	Eisen et al. 2017 County Status for *I. scapularis*	TickSpotters (2014-2019) County Status for *I. scapularis*
20161	Riley	Kansas	Reported	No record
20177	Shawnee	Kansas	Reported	No record
21047	Christian	Kentucky	Reported	No record
21091	Hancock	Kentucky	Reported	No record
21227	Warren	Kentucky	Reported	No record
22033	East Baton Rouge	Louisiana	Reported	No record
22035	East Carroll	Louisiana	Reported	No record
22053	Jefferson Davis	Louisiana	Reported	No record
22065	Madison	Louisiana	Reported	No record
22073	Ouachita	Louisiana	Reported	No record
22077	Pointe Coupee	Louisiana	Reported	No record
22085	Sabine	Louisiana	Reported	No record
22107	Tensas	Louisiana	Reported	No record
22113	Vermilion	Louisiana	Reported	No record
22127	Winn	Louisiana	Reported	No record
26013	Baraga	Michigan	Reported	No record
26059	Hillsdale	Michigan	Reported	No record
26071	Iron	Michigan	Reported	No record
26097	Mackinac	Michigan	Reported	No record
27015	Brown	Minnesota	Reported	No record
27103	Nicollet	Minnesota	Reported	No record
28001	Adams	Mississippi	Reported	No record
28003	Alcorn	Mississippi	Reported	No record
28005	Amite	Mississippi	Reported	No record
28009	Benton	Mississippi	Reported	No record
28013	Calhoun	Mississippi	Reported	No record
28015	Carroll	Mississippi	Reported	No record
28017	Chickasaw	Mississippi	Reported	No record
28019	Choctaw	Mississippi	Reported	No record
28021	Claiborne	Mississippi	Reported	No record
28023	Clarke	Mississippi	Reported	No record
28025	Clay	Mississippi	Reported	No record
28027	Coahoma	Mississippi	Reported	No record
28031	Covington	Mississippi	Reported	No record
28037	Franklin	Mississippi	Reported	No record
28039	George	Mississippi	Reported	No record
28041	Greene	Mississippi	Reported	No record
28043	Grenada	Mississippi	Reported	No record
28045	Hancock	Mississippi	Reported	No record
28051	Holmes	Mississippi	Reported	No record
28053	Humphreys	Mississippi	Reported	No record
28055	Issaquena	Mississippi	Reported	No record
28057	Itawamba	Mississippi	Reported	No record
28061	Jasper	Mississippi	Reported	No record
28065	Jefferson Davis	Mississippi	Reported	No record
28067	Jones	Mississippi	Reported	No record
28069	Kemper	Mississippi	Reported	No record
28073	Lamar	Mississippi	Reported	No record
28075	Lauderdale	Mississippi	Reported	No record
28077	Lawrence	Mississippi	Reported	No record
28079	Leake	Mississippi	Reported	No record
28081	Lee	Mississippi	Reported	No record
28083	Leflore	Mississippi	Reported	No record
28085	Lincoln	Mississippi	Reported	No record
28087	Lowndes	Mississippi	Reported	No record
28089	Madison	Mississippi	Reported	No record
28095	Monroe	Mississippi	Reported	No record
28097	Montgomery	Mississippi	Reported	No record

FIPS	County	State	Eisen et al. 2017 County Status for *I. scapularis*	TickSpotters (2014-2019) County Status for *I. scapularis*
28099	Neshoba	Mississippi	Reported	No record
28107	Panola	Mississippi	Reported	No record
28109	Pearl River	Mississippi	Reported	No record
28113	Pike	Mississippi	Reported	No record
28115	Pontotoc	Mississippi	Reported	No record
28117	Prentiss	Mississippi	Reported	No record
28119	Quitman	Mississippi	Reported	No record
28125	Sharkey	Mississippi	Reported	No record
28127	Simpson	Mississippi	Reported	No record
28129	Smith	Mississippi	Reported	No record
28131	Stone	Mississippi	Reported	No record
28133	Sunflower	Mississippi	Reported	No record
28135	Tallahatchie	Mississippi	Reported	No record
28137	Tate	Mississippi	Reported	No record
28139	Tippah	Mississippi	Reported	No record
28141	Tishomingo	Mississippi	Reported	No record
28143	Tunica	Mississippi	Reported	No record
28145	Union	Mississippi	Reported	No record
28147	Walthall	Mississippi	Reported	No record
28151	Washington	Mississippi	Reported	No record
28153	Wayne	Mississippi	Reported	No record
28155	Webster	Mississippi	Reported	No record
28157	Wilkinson	Mississippi	Reported	No record
28161	Yalobusha	Mississippi	Reported	No record
28163	Yazoo	Mississippi	Reported	No record
29045	Clark	Missouri	Reported	No record
29139	Montgomery	Missouri	Reported	No record
29143	New Madrid	Missouri	Reported	No record
29145	Newton	Missouri	Reported	No record
29201	Scott	Missouri	Reported	No record
31025	Cass	Nebraska	Reported	No record
31109	Lancaster	Nebraska	Reported	No record
31133	Pawnee	Nebraska	Reported	No record
33007	Coos	New Hampshire	Reported	No record
37007	Anson	North Carolina	Reported	No record
37077	Granville	North Carolina	Reported	No record
37107	Lenoir	North Carolina	Reported	No record
37147	Pitt	North Carolina	Reported	No record
37181	Vance	North Carolina	Reported	No record
38073	Ransom	North Dakota	Reported	No record
38079	Rolette	North Dakota	Reported	No record
38091	Steele	North Dakota	Reported	No record
39009	Athens	Ohio	Reported	No record
39047	Fayette	Ohio	Reported	No record
39057	Greene	Ohio	Reported	No record
39071	Highland	Ohio	Reported	No record
39097	Madison	Ohio	Reported	No record
39117	Morrow	Ohio	Reported	No record
39125	Paulding	Ohio	Reported	No record
39163	Vinton	Ohio	Reported	No record
39165	Warren	Ohio	Reported	No record
39171	Williams	Ohio	Reported	No record
40001	Adair	Oklahoma	Reported	No record
40005	Atoka	Oklahoma	Reported	No record
40015	Caddo	Oklahoma	Reported	No record
40019	Carter	Oklahoma	Reported	No record
40029	Coal	Oklahoma	Reported	No record
40031	Comanche	Oklahoma	Reported	No record

FIPS	County	State	Eisen et al. 2017 County Status for *I. scapularis*	TickSpotters (2014-2019) County Status for *I. scapularis*
40037	Creek	Oklahoma	Reported	No record
40041	Delaware	Oklahoma	Reported	No record
40047	Garfield	Oklahoma	Reported	No record
40049	Garvin	Oklahoma	Reported	No record
40061	Haskell	Oklahoma	Reported	No record
40063	Hughes	Oklahoma	Reported	No record
40069	Johnston	Oklahoma	Reported	No record
40077	Latimer	Oklahoma	Reported	No record
40081	Lincoln	Oklahoma	Reported	No record
40085	Love	Oklahoma	Reported	No record
40097	Mayes	Oklahoma	Reported	No record
40099	Murray	Oklahoma	Reported	No record
40101	Muskogee	Oklahoma	Reported	No record
40111	Okmulgee	Oklahoma	Reported	No record
40115	Ottawa	Oklahoma	Reported	No record
40117	Pawnee	Oklahoma	Reported	No record
40121	Pittsburg	Oklahoma	Reported	No record
40123	Pontotoc	Oklahoma	Reported	No record
40125	Pottawatomie	Oklahoma	Reported	No record
40127	Pushmataha	Oklahoma	Reported	No record
40131	Rogers	Oklahoma	Reported	No record
40133	Seminole	Oklahoma	Reported	No record
40135	Sequoyah	Oklahoma	Reported	No record
40147	Washington	Oklahoma	Reported	No record
45001	Abbeville	South Carolina	Reported	No record
45005	Allendale	South Carolina	Reported	No record
45007	Anderson	South Carolina	Reported	No record
45017	Calhoun	South Carolina	Reported	No record
45025	Chesterfield	South Carolina	Reported	No record
45029	Colleton	South Carolina	Reported	No record
45031	Darlington	South Carolina	Reported	No record
45035	Dorchester	South Carolina	Reported	No record
45039	Fairfield	South Carolina	Reported	No record
45045	Greenville	South Carolina	Reported	No record
45047	Greenwood	South Carolina	Reported	No record
45059	Laurens	South Carolina	Reported	No record
45077	Pickens	South Carolina	Reported	No record
45081	Saluda	South Carolina	Reported	No record
46011	Brookings	South Dakota	Reported	No record
46029	Codington	South Dakota	Reported	No record
47007	Bledsoe	Tennessee	Reported	No record
47025	Claiborne	Tennessee	Reported	No record
47027	Clay	Tennessee	Reported	No record
47035	Cumberland	Tennessee	Reported	No record
47049	Fentress	Tennessee	Reported	No record
47055	Giles	Tennessee	Reported	No record
47057	Grainger	Tennessee	Reported	No record
47079	Henry	Tennessee	Reported	No record
47085	Humphreys	Tennessee	Reported	No record
47095	Lake	Tennessee	Reported	No record
47097	Lauderdale	Tennessee	Reported	No record
47131	Obion	Tennessee	Reported	No record
47137	Pickett	Tennessee	Reported	No record
47149	Rutherford	Tennessee	Reported	No record
47151	Scott	Tennessee	Reported	No record
47153	Sequatchie	Tennessee	Reported	No record
47161	Stewart	Tennessee	Reported	No record
47165	Sumner	Tennessee	Reported	No record

FIPS	County	State	Eisen et al. 2017 County Status for *I. scapularis*	TickSpotters (2014-2019) County Status for *I. scapularis*
47167	Tipton	Tennessee	Reported	No record
47177	Warren	Tennessee	Reported	No record
47181	Wayne	Tennessee	Reported	No record
47185	White	Tennessee	Reported	No record
47187	Williamson	Tennessee	Reported	No record
48015	Austin	Texas	Reported	No record
48019	Bandera	Texas	Reported	No record
48021	Bastrop	Texas	Reported	No record
48031	Blanco	Texas	Reported	No record
48037	Bowie	Texas	Reported	No record
48099	Coryell	Texas	Reported	No record
48137	Edwards	Texas	Reported	No record
48159	Franklin	Texas	Reported	No record
48193	Hamilton	Texas	Reported	No record
48231	Hunt	Texas	Reported	No record
48265	Kerr	Texas	Reported	No record
48273	Kleberg	Texas	Reported	No record
48277	Lamar	Texas	Reported	No record
48281	Lampasas	Texas	Reported	No record
48291	Liberty	Texas	Reported	No record
48299	Llano	Texas	Reported	No record
48319	Mason	Texas	Reported	No record
48321	Matagorda	Texas	Reported	No record
48351	Newton	Texas	Reported	No record
48363	Palo Pinto	Texas	Reported	No record
48395	Robertson	Texas	Reported	No record
48403	Sabine	Texas	Reported	No record
48419	Shelby	Texas	Reported	No record
48435	Sutton	Texas	Reported	No record
48441	Taylor	Texas	Reported	No record
48459	Upshur	Texas	Reported	No record
48463	Uvalde	Texas	Reported	No record
48469	Victoria	Texas	Reported	No record
48507	Zavala	Texas	Reported	No record
05013	Calhoun	Arkansas	Reported	No record
05027	Columbia	Arkansas	Reported	No record
05029	Conway	Arkansas	Reported	No record
05039	Dallas	Arkansas	Reported	No record
05043	Drew	Arkansas	Reported	No record
05061	Howard	Arkansas	Reported	No record
05065	Izard	Arkansas	Reported	No record
05069	Jefferson	Arkansas	Reported	No record
05071	Johnson	Arkansas	Reported	No record
05073	Lafayette	Arkansas	Reported	No record
05079	Lincoln	Arkansas	Reported	No record
05083	Logan	Arkansas	Reported	No record
05097	Montgomery	Arkansas	Reported	No record
05099	Nevada	Arkansas	Reported	No record
51005	Alleghany	Virginia	Reported	No record
05101	Newton	Arkansas	Reported	No record
51025	Brunswick	Virginia	Reported	No record
05103	Ouachita	Arkansas	Reported	No record
51036	Charles City	Virginia	Reported	No record
05105	Perry	Arkansas	Reported	No record
51053	Dinwiddie	Virginia	Reported	No record
51057	Essex	Virginia	Reported	No record
51073	Gloucester	Virginia	Reported	No record
51081	Greensville	Virginia	Reported	No record

FIPS	County	State	Eisen et al. 2017 County Status for *I. scapularis*	TickSpotters (2014-2019) County Status for *I. scapularis*
05109	Pike	Arkansas	Reported	No record
51133	Northumberland	Virginia	Reported	No record
51147	Prince Edward	Virginia	Reported	No record
51149	Prince George	Virginia	Reported	No record
51157	Rappahannock	Virginia	Reported	No record
51159	Richmond	Virginia	Reported	No record
51183	Sussex	Virginia	Reported	No record
05121	Randolph	Arkansas	Reported	No record
05127	Scott	Arkansas	Reported	No record
05135	Sharp	Arkansas	Reported	No record
05141	Van Buren	Arkansas	Reported	No record
05149	Yell	Arkansas	Reported	No record
54017	Doddridge	West Virginia	Reported	No record
54023	Grant	West Virginia	Reported	No record
54035	Jackson	West Virginia	Reported	No record
54043	Lincoln	West Virginia	Reported	No record
54045	Logan	West Virginia	Reported	No record
54051	Marshall	West Virginia	Reported	No record
54057	Mineral	West Virginia	Reported	No record
54075	Pocahontas	West Virginia	Reported	No record
54085	Ritchie	West Virginia	Reported	No record
55037	Florence	Wisconsin	Reported	No record
01003	Baldwin	Alabama	Reported	Reported
01031	Coffee	Alabama	Reported	Reported
01045	Dale	Alabama	Reported	Reported
01069	Houston	Alabama	Reported	Reported
01073	Jefferson	Alabama	Reported	Reported
01101	Montgomery	Alabama	Reported	Reported
01125	Tuscaloosa	Alabama	Reported	Reported
12009	Brevard	Florida	Reported	Reported
12011	Broward	Florida	Reported	Reported
12081	Manatee	Florida	Reported	Reported
12101	Pasco	Florida	Reported	Reported
12133	Washington	Florida	Reported	Reported
13009	Baldwin	Georgia	Reported	Reported
13021	Bibb	Georgia	Reported	Reported
13027	Brooks	Georgia	Reported	Reported
13029	Bryan	Georgia	Reported	Reported
13039	Camden	Georgia	Reported	Reported
13053	Chattahoochee	Georgia	Reported	Reported
13059	Clarke	Georgia	Reported	Reported
13073	Columbia	Georgia	Reported	Reported
13117	Forsyth	Georgia	Reported	Reported
13215	Muscogee	Georgia	Reported	Reported
17007	Boone	Illinois	Reported	Reported
17095	Knox	Illinois	Reported	Reported
17177	Stephenson	Illinois	Reported	Reported
18001	Adams	Indiana	Reported	Reported
18013	Brown	Indiana	Reported	Reported
18029	Dearborn	Indiana	Reported	Reported
18039	Elkhart	Indiana	Reported	Reported
18055	Greene	Indiana	Reported	Reported
18063	Hendricks	Indiana	Reported	Reported
18067	Howard	Indiana	Reported	Reported
18099	Marshall	Indiana	Reported	Reported
18117	Orange	Indiana	Reported	Reported
18151	Steuben	Indiana	Reported	Reported
18155	Switzerland	Indiana	Reported	Reported

FIPS	County	State	Eisen et al. 2017 County Status for *I. scapularis*	TickSpotters (2014-2019) County Status for *I. scapularis*
18163	Vanderburgh	Indiana	Reported	Reported
19011	Benton	Iowa	Reported	Reported
19049	Dallas	Iowa	Reported	Reported
19061	Dubuque	Iowa	Reported	Reported
19095	Iowa	Iowa	Reported	Reported
19115	Louisa	Iowa	Reported	Reported
19183	Washington	Iowa	Reported	Reported
20091	Johnson	Kansas	Reported	Reported
21007	Ballard	Kentucky	Reported	Reported
22015	Bossier	Louisiana	Reported	Reported
22025	Catahoula	Louisiana	Reported	Reported
22027	Claiborne	Louisiana	Reported	Reported
22031	De Soto	Louisiana	Reported	Reported
22055	Lafayette	Louisiana	Reported	Reported
22079	Rapides	Louisiana	Reported	Reported
22105	Tangipahoa	Louisiana	Reported	Reported
22117	Washington	Louisiana	Reported	Reported
24023	Garrett	Maryland	Reported	Reported
26003	Alger	Michigan	Reported	Reported
26037	Clinton	Michigan	Reported	Reported
26047	Emmet	Michigan	Reported	Reported
26061	Houghton	Michigan	Reported	Reported
26075	Jackson	Michigan	Reported	Reported
26087	Lapeer	Michigan	Reported	Reported
26103	Marquette	Michigan	Reported	Reported
26111	Midland	Michigan	Reported	Reported
27131	Rice	Minnesota	Reported	Reported
28007	Attala	Mississippi	Reported	Reported
28035	Forrest	Mississippi	Reported	Reported
28047	Harrison	Mississippi	Reported	Reported
28063	Jefferson	Mississippi	Reported	Reported
28071	Lafayette	Mississippi	Reported	Reported
28091	Marion	Mississippi	Reported	Reported
28101	Newton	Mississippi	Reported	Reported
28149	Warren	Mississippi	Reported	Reported
29019	Boone	Missouri	Reported	Reported
36073	Orleans	New York	Reported	Reported
37035	Catawba	North Carolina	Reported	Reported
37067	Forsyth	North Carolina	Reported	Reported
37087	Haywood	North Carolina	Reported	Reported
37119	Mecklenburg	North Carolina	Reported	Reported
37125	Moore	North Carolina	Reported	Reported
37139	Pasquotank	North Carolina	Reported	Reported
37151	Randolph	North Carolina	Reported	Reported
37161	Rutherford	North Carolina	Reported	Reported
37171	Surry	North Carolina	Reported	Reported
39005	Ashland	Ohio	Reported	Reported
39011	Auglaize	Ohio	Reported	Reported
39015	Brown	Ohio	Reported	Reported
39017	Butler	Ohio	Reported	Reported
39025	Clermont	Ohio	Reported	Reported
39041	Delaware	Ohio	Reported	Reported
39043	Erie	Ohio	Reported	Reported
39045	Fairfield	Ohio	Reported	Reported
39105	Meigs	Ohio	Reported	Reported
39113	Montgomery	Ohio	Reported	Reported
39123	Ottawa	Ohio	Reported	Reported
39129	Pickaway	Ohio	Reported	Reported

FIPS	County	State	Eisen et al. 2017 County Status for *I. scapularis*	TickSpotters (2014-2019) County Status for *I. scapularis*
39145	Scioto	Ohio	Reported	Reported
39159	Union	Ohio	Reported	Reported
39167	Washington	Ohio	Reported	Reported
39173	Wood	Ohio	Reported	Reported
40109	Oklahoma	Oklahoma	Reported	Reported
40119	Payne	Oklahoma	Reported	Reported
40143	Tulsa	Oklahoma	Reported	Reported
40145	Wagoner	Oklahoma	Reported	Reported
45051	Horry	South Carolina	Reported	Reported
45075	Orangeburg	South Carolina	Reported	Reported
45079	Richland	South Carolina	Reported	Reported
45083	Spartanburg	South Carolina	Reported	Reported
45085	Sumter	South Carolina	Reported	Reported
47119	Maury	Tennessee	Reported	Reported
47125	Montgomery	Tennessee	Reported	Reported
47145	Roane	Tennessee	Reported	Reported
48061	Cameron	Texas	Reported	Reported
48089	Colorado	Texas	Reported	Reported
48113	Dallas	Texas	Reported	Reported
48157	Fort Bend	Texas	Reported	Reported
48181	Grayson	Texas	Reported	Reported
48183	Gregg	Texas	Reported	Reported
48203	Harrison	Texas	Reported	Reported
48209	Hays	Texas	Reported	Reported
48215	Hidalgo	Texas	Reported	Reported
48225	Houston	Texas	Reported	Reported
48245	Jefferson	Texas	Reported	Reported
48401	Rusk	Texas	Reported	Reported
48405	San Augustine	Texas	Reported	Reported
48471	Walker	Texas	Reported	Reported
48477	Washington	Texas	Reported	Reported
50019	Orleans	Vermont	Reported	Reported
05015	Carroll	Arkansas	Reported	Reported
51017	Bath	Virginia	Reported	Reported
51047	Culpeper	Virginia	Reported	Reported
51049	Cumberland	Virginia	Reported	Reported
51085	Hanover	Virginia	Reported	Reported
51103	Lancaster	Virginia	Reported	Reported
51117	Mecklenburg	Virginia	Reported	Reported
51171	Shenandoah	Virginia	Reported	Reported
51177	Spotsylvania	Virginia	Reported	Reported
05119	Pulaski	Arkansas	Reported	Reported
51191	Washington	Virginia	Reported	Reported
51710	Norfolk	Virginia	Reported	Reported
54005	Boone	West Virginia	Reported	Reported
54011	Cabell	West Virginia	Reported	Reported
54019	Fayette	West Virginia	Reported	Reported
54027	Hampshire	West Virginia	Reported	Reported
54065	Morgan	West Virginia	Reported	Reported
54069	Ohio	West Virginia	Reported	Reported
54079	Putnam	West Virginia	Reported	Reported
54083	Randolph	West Virginia	Reported	Reported
54093	Tucker	West Virginia	Reported	Reported
54095	Tyler	West Virginia	Reported	Reported
55027	Dodge	Wisconsin	Reported	Reported
55059	Kenosha	Wisconsin	Reported	Reported
55065	Lafayette	Wisconsin	Reported	Reported
55071	Manitowoc	Wisconsin	Reported	Reported

FIPS	County	State	Eisen et al. 2017 County Status for *I. scapularis*	TickSpotters (2014-2019) County Status for *I. scapularis*
55087	Outagamie	Wisconsin	Reported	Reported
55093	Pierce	Wisconsin	Reported	Reported
55115	Shawano	Wisconsin	Reported	Reported
55123	Vernon	Wisconsin	Reported	Reported
55137	Waushara	Wisconsin	Reported	Reported
55139	Winnebago	Wisconsin	Reported	Reported

Appendix 5. Comparison of United States counties with presence of *Ixodes pacificus* as reported by Eisen et al. 2017 and the TickSpotters program (2014-2019).

FIPS	County	State	Eisen et al. 2017 County Status for *I. pacificus*	TickSpotters (2014-2019) County Status for *I. pacificus*
06001	Alameda	California	Established	Established
06013	Contra Costa	California	Established	Established
06017	El Dorado	California	Established	Established
06023	Humboldt	California	Established	Established
06037	Los Angeles	California	Established	Established
06041	Marin	California	Established	Established
06045	Mendocino	California	Established	Established
06053	Monterey	California	Established	Established
06057	Nevada	California	Established	Established
06059	Orange	California	Established	Established
06061	Placer	California	Established	Established
06067	Sacramento	California	Established	Established
06071	San Bernardino	California	Established	Established
06073	San Diego	California	Established	Established
06075	San Francisco	California	Established	Established
06079	San Luis Obispo	California	Established	Established
06081	San Mateo	California	Established	Established
06083	Santa Barbara	California	Established	Established
06085	Santa Clara	California	Established	Established
06087	Santa Cruz	California	Established	Established
06097	Sonoma	California	Established	Established
06111	Ventura	California	Established	Established
41019	Douglas	Oregon	Established	Established
41029	Jackson	Oregon	Established	Established
41039	Lane	Oregon	Established	Established
41051	Multnomah	Oregon	Established	Established
41067	Washington	Oregon	Established	Established
53011	Clark	Washington	Established	Established
53033	King	Washington	Established	Established
53039	Klickitat	Washington	Established	Established
53067	Thurston	Washington	Established	Established
06069	San Benito	California	Established	No record
41055	Sherman	Oregon	Established	No record
06091	Sierra	California	Established	No record
06101	Sutter	California	Established	No record

FIPS	County	State	Eisen et al. 2017 County Status for *I. pacificus*	TickSpotters (2014-2019) County Status for *I. pacificus*
49045	Tooele	Utah	Established	No record
49049	Utah	Utah	Established	No record
53009	Clallam	Washington	Established	No record
41007	Clatsop	Oregon	Established	No record
06011	Colusa	California	Established	No record
06021	Glenn	California	Established	No record
06025	Imperial	California	Established	No record
06027	Inyo	California	Established	No record
53031	Jefferson	Washington	Established	No record
49023	Juab	Utah	Established	No record
06005	Amador	California	Established	No record
04015	Mohave	Arizona	Established	No record
06063	Plumas	California	Established	No record
06039	Madera	California	Established	No record
06047	Merced	California	Established	No record
06035	Lassen	California	Established	No record
06007	Butte	California	Established	Reported
06009	Calaveras	California	Established	Reported
06015	Del Norte	California	Established	Reported
06019	Fresno	California	Established	Reported
06029	Kern	California	Established	Reported
06031	Kings	California	Established	Reported
06033	Lake	California	Established	Reported
06043	Mariposa	California	Established	Reported
06055	Napa	California	Established	Reported
06065	Riverside	California	Established	Reported
06077	San Joaquin	California	Established	Reported
06089	Shasta	California	Established	Reported
06093	Siskiyou	California	Established	Reported
06095	Solano	California	Established	Reported
06099	Stanislaus	California	Established	Reported
06103	Tehama	California	Established	Reported
06105	Trinity	California	Established	Reported
06107	Tulare	California	Established	Reported
06109	Tuolumne	California	Established	Reported
06113	Yolo	California	Established	Reported
06115	Yuba	California	Established	Reported

FIPS	County	State	Eisen et al. 2017 County Status for *I. pacificus*	TickSpotters (2014-2019) County Status for *I. pacificus*
41003	Benton	Oregon	Established	Reported
41005	Clackamas	Oregon	Established	Reported
41011	Coos	Oregon	Established	Reported
41015	Curry	Oregon	Established	Reported
41027	Hood River	Oregon	Established	Reported
41033	Josephine	Oregon	Established	Reported
41041	Lincoln	Oregon	Established	Reported
41043	Linn	Oregon	Established	Reported
41047	Marion	Oregon	Established	Reported
41057	Tillamook	Oregon	Established	Reported
41065	Wasco	Oregon	Established	Reported
49035	Salt Lake	Utah	Established	Reported
49053	Washington	Utah	Established	Reported
53007	Chelan	Washington	Established	Reported
53015	Cowlitz	Washington	Established	Reported
53035	Kitsap	Washington	Established	Reported
53041	Lewis	Washington	Established	Reported
53045	Mason	Washington	Established	Reported
53057	Skagit	Washington	Established	Reported
53059	Skamania	Washington	Established	Reported
53073	Whatcom	Washington	Established	Reported
53053	Pierce:penrose	Washington	No record	Established
53053	Pierce:penrose	Washington	No record	Established
53053	Pierce:main	Washington	No record	Established
53053	Pierce:main	Washington	No record	Established
08069	Larimer	Colorado	No record	Reported
08117	Summit	Colorado	No record	Reported
16013	Blaine	Idaho	No record	Reported
32005	Douglas	Nevada	No record	Reported
32031	Washoe	Nevada	No record	Reported
41017	Deschutes	Oregon	No record	Reported
41071	Yamhill	Oregon	No record	Reported
49021	Iron	Utah	No record	Reported
49047	Uintah	Utah	No record	Reported
53055	San Juan:San Juan Island	Washington	No record	Reported
53055	San Juan:San Juan Island	Washington	No record	Reported
53055	San Juan:San Juan Island	Washington	No record	Reported

FIPS	County	State	Eisen et al. 2017 County Status for *I. pacificus*	TickSpotters (2014-2019) County Status for *I. pacificus*
53055	San Juan:Orcas Island	Washington	No record	Reported
53055	San Juan:Orcas Island	Washington	No record	Reported
53055	San Juan:Orcas Island	Washington	No record	Reported
53055	San Juan:Lopez Island	Washington	No record	Reported
53055	San Juan:Lopez Island	Washington	No record	Reported
53055	San Juan:Lopez Island	Washington	No record	Reported
53061	Snohomish	Washington	Reported	Established
41059	Umatilla	Oregon	Reported	No record
49001	Beaver	Utah	Reported	No record
41031	Jefferson	Oregon	Reported	No record
32003	Clark	Nevada	Reported	No record
32017	Lincoln	Nevada	Reported	No record
49027	Millard	Utah	Reported	No record
06051	Mono	California	Reported	No record
53047	Okanogan	Washington	Reported	No record
49031	Piute	Utah	Reported	No record
41053	Polk	Oregon	Reported	No record
41009	Columbia	Oregon	Reported	Reported
53029	Island	Washington	Reported	Reported
53037	Kittitas	Washington	Reported	Reported
53049	Pacific	Washington	Reported	Reported
53077	Yakima	Washington	Reported	Reported

Appendix 6. Comparison of United States counties with presence of *Amblyomma americanum* as reported by Springer et al. 2014 and the TickSpotters program (2014-2019).

FIPS	County	State	Springer et al. 2014 County Status for *A. americanum*	TickSpotters (2014-2019) County Status for *A. americanum*
01081	Lee	Alabama	Established	Established
01089	Madison	Alabama	Established	Established
11001	Washington	District Of Columbia	Established	Established
01117	Shelby	Alabama	Established	Established
12001	Alachua	Florida	Established	Established
12017	Citrus	Florida	Established	Established
12019	Clay	Florida	Established	Established
12031	Duval	Florida	Established	Established
12057	Hillsborough	Florida	Established	Established
12069	Lake	Florida	Established	Established
12073	Leon	Florida	Established	Established
12083	Marion	Florida	Established	Established
12095	Orange	Florida	Established	Established
12101	Pasco	Florida	Established	Established
12109	St Johns	Florida	Established	Established
12117	Seminole	Florida	Established	Established
12127	Volusia	Florida	Established	Established
12129	Wakulla	Florida	Established	Established
13021	Bibb	Georgia	Established	Established
13051	Chatham	Georgia	Established	Established
13059	Clarke	Georgia	Established	Established
13127	Glynn	Georgia	Established	Established
13133	Greene	Georgia	Established	Established
13135	Gwinnett	Georgia	Established	Established
13153	Houston	Georgia	Established	Established
13215	Muscogee	Georgia	Established	Established
13217	Newton	Georgia	Established	Established
18043	Floyd	Indiana	Established	Established
18105	Monroe	Indiana	Established	Established
18163	Vanderburgh	Indiana	Established	Established
19153	Polk	Iowa	Established	Established
20161	Riley	Kansas	Established	Established
21061	Edmonson	Kentucky	Established	Established

FIPS	County	State	Springer et al. 2014 County Status for *A. americanum*	TickSpotters (2014-2019) County Status for *A. americanum*
21111	Jefferson	Kentucky	Established	Established
21221	Trigg	Kentucky	Established	Established
21227	Warren	Kentucky	Established	Established
24003	Anne Arundel	Maryland	Established	Established
24005	Baltimore	Maryland	Established	Established
24009	Calvert	Maryland	Established	Established
24015	Cecil	Maryland	Established	Established
24017	Charles	Maryland	Established	Established
24019	Dorchester	Maryland	Established	Established
24025	Harford	Maryland	Established	Established
24029	Kent	Maryland	Established	Established
24031	Montgomery	Maryland	Established	Established
24033	Prince Georges	Maryland	Established	Established
24035	Queen Annes	Maryland	Established	Established
24037	St Marys	Maryland	Established	Established
24045	Wicomico	Maryland	Established	Established
24047	Worcester	Maryland	Established	Established
29019	Boone	Missouri	Established	Established
29029	Camden	Missouri	Established	Established
29047	Clay	Missouri	Established	Established
29071	Franklin	Missouri	Established	Established
29077	Greene	Missouri	Established	Established
29095	Jackson	Missouri	Established	Established
29099	Jefferson	Missouri	Established	Established
29161	Phelps	Missouri	Established	Established
29169	Pulaski	Missouri	Established	Established
29183	St Charles	Missouri	Established	Established
29189	St Louis	Missouri	Established	Established
29213	Taney	Missouri	Established	Established
34001	Atlantic	New Jersey	Established	Established
34005	Burlington	New Jersey	Established	Established
34025	Monmouth	New Jersey	Established	Established
34029	Ocean	New Jersey	Established	Established
36059	Nassau	New York	Established	Established
36103	Suffolk	New York	Established	Established
36119	Westchester	New York	Established	Established
37001	Alamance	North Carolina	Established	Established

FIPS	County	State	Springer et al. 2014 County Status for *A. americanum*	TickSpotters (2014-2019) County Status for *A. americanum*
37019	Brunswick	North Carolina	Established	Established
37037	Chatham	North Carolina	Established	Established
37049	Craven	North Carolina	Established	Established
37053	Currituck:knotts	North Carolina	Established	Established
37053	Currituck:knotts	North Carolina	Established	Established
37053	Currituck:knotts	North Carolina	Established	Established
37053	Currituck:main	North Carolina	Established	Established
37053	Currituck:main	North Carolina	Established	Established
37053	Currituck:main	North Carolina	Established	Established
37053	Currituck:spit	North Carolina	Established	Established
37053	Currituck:spit	North Carolina	Established	Established
37053	Currituck:spit	North Carolina	Established	Established
37055	Dare	North Carolina	Established	Established
37077	Granville	North Carolina	Established	Established
37125	Moore	North Carolina	Established	Established
37133	Onslow	North Carolina	Established	Established
37151	Randolph	North Carolina	Established	Established
37183	Wake	North Carolina	Established	Established
40089	Mccurtain	Oklahoma	Established	Established
44005	Newport	Rhode Island	Established	Established
45013	Beaufort	South Carolina	Established	Established
45019	Charleston	South Carolina	Established	Established
45051	Horry	South Carolina	Established	Established
47001	Anderson	Tennessee	Established	Established
47035	Cumberland	Tennessee	Established	Established
47037	Davidson	Tennessee	Established	Established
47043	Dickson	Tennessee	Established	Established
47065	Hamilton	Tennessee	Established	Established
47125	Montgomery	Tennessee	Established	Established
47149	Rutherford	Tennessee	Established	Established
47157	Shelby	Tennessee	Established	Established
47165	Sumner	Tennessee	Established	Established
47187	Williamson	Tennessee	Established	Established
47189	Wilson	Tennessee	Established	Established
48113	Dallas	Texas	Established	Established
48121	Denton	Texas	Established	Established
48215	Hidalgo	Texas	Established	Established

FIPS	County	State	Springer et al. 2014 County Status for *A. americanum*	TickSpotters (2014-2019) County Status for *A. americanum*
48439	Tarrant	Texas	Established	Established
48453	Travis	Texas	Established	Established
05007	Benton	Arkansas	Established	Established
05051	Garland	Arkansas	Established	Established
51041	Chesterfield	Virginia	Established	Established
51059	Fairfax	Virginia	Established	Established
51075	Goochland	Virginia	Established	Established
51085	Hanover	Virginia	Established	Established
51095	James City	Virginia	Established	Established
51109	Louisa	Virginia	Established	Established
51137	Orange	Virginia	Established	Established
51153	Prince William	Virginia	Established	Established
51177	Spotsylvania	Virginia	Established	Established
05119	Pulaski	Arkansas	Established	Established
51199	York	Virginia	Established	Established
05125	Saline	Arkansas	Established	Established
05143	Washington	Arkansas	Established	Established
51700	Newport News	Virginia	Established	Established
51800	Suffolk	Virginia	Established	Established
09001	Fairfield	Connecticut	Established	Established
09009	New Haven	Connecticut	Established	Established
01017	Chambers	Alabama	Established	No record
01023	Choctaw	Alabama	Established	No record
01025	Clarke	Alabama	Established	No record
01033	Colbert	Alabama	Established	No record
01037	Coosa	Alabama	Established	No record
01053	Escambia	Alabama	Established	No record
01065	Hale	Alabama	Established	No record
01069	Houston	Alabama	Established	No record
01113	Russell	Alabama	Established	No record
01123	Tallapoosa	Alabama	Established	No record
01131	Wilcox	Alabama	Established	No record
12003	Baker	Florida	Established	No record
12037	Franklin	Florida	Established	No record
12043	Glades	Florida	Established	No record
12055	Highlands	Florida	Established	No record
12059	Holmes	Florida	Established	No record

FIPS	County	State	Springer et al. 2014 County Status for *A. americanum*	TickSpotters (2014-2019) County Status for *A. americanum*
12067	Lafayette	Florida	Established	No record
12079	Madison	Florida	Established	No record
12085	Martin	Florida	Established	No record
13005	Bacon	Georgia	Established	No record
13015	Bartow	Georgia	Established	No record
13025	Brantley	Georgia	Established	No record
13029	Bryan	Georgia	Established	No record
13069	Coffee	Georgia	Established	No record
13131	Grady	Georgia	Established	No record
13141	Hancock	Georgia	Established	No record
13147	Hart	Georgia	Established	No record
13163	Jefferson	Georgia	Established	No record
13179	Liberty	Georgia	Established	No record
13181	Lincoln	Georgia	Established	No record
13191	Mcintosh	Georgia	Established	No record
13207	Monroe	Georgia	Established	No record
13211	Morgan	Georgia	Established	No record
13263	Talbot	Georgia	Established	No record
13275	Thomas	Georgia	Established	No record
13299	Ware	Georgia	Established	No record
13301	Warren	Georgia	Established	No record
17149	Pike	Illinois	Established	No record
18025	Crawford	Indiana	Established	No record
18125	Pike	Indiana	Established	No record
18129	Posey	Indiana	Established	No record
19013	Black Hawk	Iowa	Established	No record
19039	Clarke	Iowa	Established	No record
19049	Dallas	Iowa	Established	No record
19051	Davis	Iowa	Established	No record
19057	Des Moines	Iowa	Established	No record
19071	Fremont	Iowa	Established	No record
19087	Henry	Iowa	Established	No record
19101	Jefferson	Iowa	Established	No record
19109	Kossuth	Iowa	Established	No record
19135	Monroe	Iowa	Established	No record
19137	Montgomery	Iowa	Established	No record
19139	Muscatine	Iowa	Established	No record

FIPS	County	State	Springer et al. 2014 County Status for *A. americanum*	TickSpotters (2014-2019) County Status for *A. americanum*
19145	Page	Iowa	Established	No record
19163	Scott	Iowa	Established	No record
19169	Story	Iowa	Established	No record
19177	Van Buren	Iowa	Established	No record
20099	Labette	Kansas	Established	No record
20191	Sumner	Kansas	Established	No record
22009	Avoyelles	Louisiana	Established	No record
22021	Caldwell	Louisiana	Established	No record
22029	Concordia	Louisiana	Established	No record
22031	De Soto	Louisiana	Established	No record
22035	East Carroll	Louisiana	Established	No record
22065	Madison	Louisiana	Established	No record
22079	Rapides	Louisiana	Established	No record
22085	Sabine	Louisiana	Established	No record
22111	Union	Louisiana	Established	No record
22127	Winn	Louisiana	Established	No record
26065	Ingham	Michigan	Established	No record
26121	Muskegon	Michigan	Established	No record
26141	Presque Isle	Michigan	Established	No record
28007	Attala	Mississippi	Established	No record
28011	Bolivar	Mississippi	Established	No record
28017	Chickasaw	Mississippi	Established	No record
28019	Choctaw	Mississippi	Established	No record
28023	Clarke	Mississippi	Established	No record
28029	Copiah	Mississippi	Established	No record
28049	Hinds	Mississippi	Established	No record
28051	Holmes	Mississippi	Established	No record
28059	Jackson	Mississippi	Established	No record
28069	Kemper	Mississippi	Established	No record
28093	Marshall	Mississippi	Established	No record
28095	Monroe	Mississippi	Established	No record
28099	Neshoba	Mississippi	Established	No record
28101	Newton	Mississippi	Established	No record
28103	Noxubee	Mississippi	Established	No record
28111	Perry	Mississippi	Established	No record
28113	Pike	Mississippi	Established	No record
28129	Smith	Mississippi	Established	No record

FIPS	County	State	Springer et al. 2014 County Status for *A. americanum*	TickSpotters (2014-2019) County Status for *A. americanum*
28141	Tishomingo	Mississippi	Established	No record
28153	Wayne	Mississippi	Established	No record
28155	Webster	Mississippi	Established	No record
28159	Winston	Mississippi	Established	No record
28163	Yazoo	Mississippi	Established	No record
29015	Benton	Missouri	Established	No record
29023	Butler	Missouri	Established	No record
29035	Carter	Missouri	Established	No record
29057	Dade	Missouri	Established	No record
29059	Dallas	Missouri	Established	No record
29073	Gasconade	Missouri	Established	No record
29085	Hickory	Missouri	Established	No record
29107	Lafayette	Missouri	Established	No record
29123	Madison	Missouri	Established	No record
29127	Marion	Missouri	Established	No record
29153	Ozark	Missouri	Established	No record
29167	Polk	Missouri	Established	No record
29181	Ripley	Missouri	Established	No record
29217	Vernon	Missouri	Established	No record
30081	Ravalli	Montana	Established	No record
31127	Nemaha	Nebraska	Established	No record
31147	Richardson	Nebraska	Established	No record
33013	Merrimack	New Hampshire	Established	No record
36001	Albany	New York	Established	No record
36007	Broome	New York	Established	No record
36021	Columbia	New York	Established	No record
36025	Delaware	New York	Established	No record
36077	Otsego	New York	Established	No record
36083	Rensselaer	New York	Established	No record
37015	Bertie	North Carolina	Established	No record
37047	Columbus	North Carolina	Established	No record
37093	Hoke	North Carolina	Established	No record
37095	Hyde	North Carolina	Established	No record
37117	Martin	North Carolina	Established	No record
37155	Robeson	North Carolina	Established	No record
37163	Sampson	North Carolina	Established	No record
37173	Swain	North Carolina	Established	No record

FIPS	County	State	Springer et al. 2014 County Status for *A. americanum*	TickSpotters (2014-2019) County Status for *A. americanum*
37187	Washington	North Carolina	Established	No record
40005	Atoka	Oklahoma	Established	No record
40013	Bryan	Oklahoma	Established	No record
40079	Le Flore	Oklahoma	Established	No record
40091	Mcintosh	Oklahoma	Established	No record
40121	Pittsburg	Oklahoma	Established	No record
45005	Allendale	South Carolina	Established	No record
45021	Cherokee	South Carolina	Established	No record
45023	Chester	South Carolina	Established	No record
45061	Lee	South Carolina	Established	No record
45067	Marion	South Carolina	Established	No record
45075	Orangeburg	South Carolina	Established	No record
45077	Pickens	South Carolina	Established	No record
47003	Bedford	Tennessee	Established	No record
47005	Benton	Tennessee	Established	No record
47017	Carroll	Tennessee	Established	No record
47021	Cheatham	Tennessee	Established	No record
47039	Decatur	Tennessee	Established	No record
47041	De Kalb	Tennessee	Established	No record
47101	Lewis	Tennessee	Established	No record
48005	Angelina	Texas	Established	No record
48009	Archer	Texas	Established	No record
48015	Austin	Texas	Established	No record
48021	Bastrop	Texas	Established	No record
48025	Bee	Texas	Established	No record
48027	Bell	Texas	Established	No record
48031	Blanco	Texas	Established	No record
48035	Bosque	Texas	Established	No record
48039	Brazoria	Texas	Established	No record
48041	Brazos	Texas	Established	No record
48049	Brown	Texas	Established	No record
48053	Burnet	Texas	Established	No record
48055	Caldwell	Texas	Established	No record
48061	Cameron	Texas	Established	No record
48067	Cass	Texas	Established	No record
48077	Clay	Texas	Established	No record
48083	Coleman	Texas	Established	No record

FIPS	County	State	Springer et al. 2014 County Status for *A. americanum*	TickSpotters (2014-2019) County Status for *A. americanum*
48089	Colorado	Texas	Established	No record
48091	Comal	Texas	Established	No record
48093	Comanche	Texas	Established	No record
48097	Cooke	Texas	Established	No record
48133	Eastland	Texas	Established	No record
48139	Ellis	Texas	Established	No record
48143	Erath	Texas	Established	No record
48145	Falls	Texas	Established	No record
48147	Fannin	Texas	Established	No record
48159	Franklin	Texas	Established	No record
48163	Frio	Texas	Established	No record
48187	Guadalupe	Texas	Established	No record
48193	Hamilton	Texas	Established	No record
48199	Hardin	Texas	Established	No record
48217	Hill	Texas	Established	No record
48221	Hood	Texas	Established	No record
48223	Hopkins	Texas	Established	No record
48225	Houston	Texas	Established	No record
48237	Jack	Texas	Established	No record
48241	Jasper	Texas	Established	No record
48245	Jefferson	Texas	Established	No record
48255	Karnes	Texas	Established	No record
48259	Kendall	Texas	Established	No record
48271	Kinney	Texas	Established	No record
48273	Kleberg	Texas	Established	No record
48277	Lamar	Texas	Established	No record
48285	Lavaca	Texas	Established	No record
48291	Liberty	Texas	Established	No record
48295	Lipscomb	Texas	Established	No record
48297	Live Oak	Texas	Established	No record
48299	Llano	Texas	Established	No record
48313	Madison	Texas	Established	No record
48319	Mason	Texas	Established	No record
48323	Maverick	Texas	Established	No record
48325	Medina	Texas	Established	No record
48333	Mills	Texas	Established	No record
48337	Montague	Texas	Established	No record

FIPS	County	State	Springer et al. 2014 County Status for *A. americanum*	TickSpotters (2014-2019) County Status for *A. americanum*
48343	Morris	Texas	Established	No record
48351	Newton	Texas	Established	No record
48353	Nolan	Texas	Established	No record
48363	Palo Pinto	Texas	Established	No record
48379	Rains	Texas	Established	No record
48391	Refugio	Texas	Established	No record
48401	Rusk	Texas	Established	No record
48407	San Jacinto	Texas	Established	No record
48409	San Patricio	Texas	Established	No record
48411	San Saba	Texas	Established	No record
48419	Shelby	Texas	Established	No record
48429	Stephens	Texas	Established	No record
48449	Titus	Texas	Established	No record
48455	Trinity	Texas	Established	No record
48479	Webb	Texas	Established	No record
48481	Wharton	Texas	Established	No record
48485	Wichita	Texas	Established	No record
48487	Wilbarger	Texas	Established	No record
48497	Wise	Texas	Established	No record
48503	Young	Texas	Established	No record
48507	Zavala	Texas	Established	No record
05001	Arkansas	Arkansas	Established	No record
05003	Ashley	Arkansas	Established	No record
05013	Calhoun	Arkansas	Established	No record
05019	Clark	Arkansas	Established	No record
05025	Cleveland	Arkansas	Established	No record
05039	Dallas	Arkansas	Established	No record
05043	Drew	Arkansas	Established	No record
05047	Franklin	Arkansas	Established	No record
05049	Fulton	Arkansas	Established	No record
05053	Grant	Arkansas	Established	No record
05057	Hempstead	Arkansas	Established	No record
05061	Howard	Arkansas	Established	No record
05071	Johnson	Arkansas	Established	No record
05077	Lee	Arkansas	Established	No record
05083	Logan	Arkansas	Established	No record
05091	Miller	Arkansas	Established	No record

FIPS	County	State	Springer et al. 2014 County Status for *A. americanum*	TickSpotters (2014-2019) County Status for *A. americanum*
05095	Monroe	Arkansas	Established	No record
51029	Buckingham	Virginia	Established	No record
05103	Ouachita	Arkansas	Established	No record
05105	Perry	Arkansas	Established	No record
51081	Greensville	Virginia	Established	No record
51121	Montgomery	Virginia	Established	No record
51135	Nottoway	Virginia	Established	No record
51159	Richmond	Virginia	Established	No record
51183	Sussex	Virginia	Established	No record
05127	Scott	Arkansas	Established	No record
05137	Stone	Arkansas	Established	No record
05139	Union	Arkansas	Established	No record
05141	Van Buren	Arkansas	Established	No record
01003	Baldwin	Alabama	Established	Reported
01013	Butler	Alabama	Established	Reported
01015	Calhoun	Alabama	Established	Reported
01029	Cleburne	Alabama	Established	Reported
01049	De Kalb	Alabama	Established	Reported
01051	Elmore	Alabama	Established	Reported
01077	Lauderdale	Alabama	Established	Reported
01079	Lawrence	Alabama	Established	Reported
01119	Sumter	Alabama	Established	Reported
01133	Winston	Alabama	Established	Reported
12005	Bay	Florida	Established	Reported
12023	Columbia	Florida	Established	Reported
12029	Dixie	Florida	Established	Reported
12039	Gadsden	Florida	Established	Reported
12041	Gilchrist	Florida	Established	Reported
12047	Hamilton	Florida	Established	Reported
12053	Hernando	Florida	Established	Reported
12063	Jackson	Florida	Established	Reported
12065	Jefferson	Florida	Established	Reported
12075	Levy	Florida	Established	Reported
12081	Manatee	Florida	Established	Reported
12086	Miami-dade	Florida	Established	Reported
12089	Nassau	Florida	Established	Reported
12093	Okeechobee	Florida	Established	Reported

FIPS	County	State	Springer et al. 2014 County Status for *A. americanum*	TickSpotters (2014-2019) County Status for *A. americanum*
12097	Osceola	Florida	Established	Reported
12105	Polk	Florida	Established	Reported
12107	Putnam	Florida	Established	Reported
12119	Sumter	Florida	Established	Reported
12121	Suwannee	Florida	Established	Reported
12123	Taylor	Florida	Established	Reported
12131	Walton	Florida	Established	Reported
12133	Washington	Florida	Established	Reported
13031	Bulloch	Georgia	Established	Reported
13039	Camden	Georgia	Established	Reported
13053	Chattahoochee	Georgia	Established	Reported
13115	Floyd	Georgia	Established	Reported
13129	Gordon	Georgia	Established	Reported
13159	Jasper	Georgia	Established	Reported
13169	Jones	Georgia	Established	Reported
13189	Mcduffie	Georgia	Established	Reported
13195	Madison	Georgia	Established	Reported
13219	Oconee	Georgia	Established	Reported
13221	Oglethorpe	Georgia	Established	Reported
13237	Putnam	Georgia	Established	Reported
13245	Richmond	Georgia	Established	Reported
13247	Rockdale	Georgia	Established	Reported
13293	Upson	Georgia	Established	Reported
13317	Wilkes	Georgia	Established	Reported
17077	Jackson	Illinois	Established	Reported
18027	Daviess	Indiana	Established	Reported
18037	Dubois	Indiana	Established	Reported
18051	Gibson	Indiana	Established	Reported
18055	Greene	Indiana	Established	Reported
18061	Harrison	Indiana	Established	Reported
18093	Lawrence	Indiana	Established	Reported
18101	Martin	Indiana	Established	Reported
18117	Orange	Indiana	Established	Reported
18123	Perry	Indiana	Established	Reported
18147	Spencer	Indiana	Established	Reported
18173	Warrick	Indiana	Established	Reported
19053	Decatur	Iowa	Established	Reported

FIPS	County	State	Springer et al. 2014 County Status for *A. americanum*	TickSpotters (2014-2019) County Status for *A. americanum*
19111	Lee	Iowa	Established	Reported
19113	Linn	Iowa	Established	Reported
19117	Lucas	Iowa	Established	Reported
19125	Marion	Iowa	Established	Reported
19179	Wapello	Iowa	Established	Reported
20017	Chase	Kansas	Established	Reported
20045	Douglas	Kansas	Established	Reported
20061	Geary	Kansas	Established	Reported
20073	Greenwood	Kansas	Established	Reported
20107	Linn	Kansas	Established	Reported
20149	Pottawatomie	Kansas	Established	Reported
20207	Woodson	Kansas	Established	Reported
21027	Breckinridge	Kentucky	Established	Reported
21093	Hardin	Kentucky	Established	Reported
21143	Lyon	Kentucky	Established	Reported
21145	Mccracken	Kentucky	Established	Reported
21151	Madison	Kentucky	Established	Reported
21217	Taylor	Kentucky	Established	Reported
22015	Bossier	Louisiana	Established	Reported
22027	Claiborne	Louisiana	Established	Reported
22033	East Baton Rouge	Louisiana	Established	Reported
22039	Evangeline	Louisiana	Established	Reported
22071	Orleans	Louisiana	Established	Reported
22115	Vernon	Louisiana	Established	Reported
22125	West Feliciana	Louisiana	Established	Reported
24011	Caroline	Maryland	Established	Reported
24039	Somerset	Maryland	Established	Reported
26125	Oakland	Michigan	Established	Reported
28001	Adams	Mississippi	Established	Reported
28021	Claiborne	Mississippi	Established	Reported
28043	Grenada	Mississippi	Established	Reported
28063	Jefferson	Mississippi	Established	Reported
28071	Lafayette	Mississippi	Established	Reported
28087	Lowndes	Mississippi	Established	Reported
28105	Oktibbeha	Mississippi	Established	Reported
28157	Wilkinson	Mississippi	Established	Reported
29001	Adair	Missouri	Established	Reported

FIPS	County	State	Springer et al. 2014 County Status for *A. americanum*	TickSpotters (2014-2019) County Status for *A. americanum*
29009	Barry	Missouri	Established	Reported
29017	Bollinger	Missouri	Established	Reported
29043	Christian	Missouri	Established	Reported
29053	Cooper	Missouri	Established	Reported
29065	Dent	Missouri	Established	Reported
29083	Henry	Missouri	Established	Reported
29093	Iron	Missouri	Established	Reported
29101	Johnson	Missouri	Established	Reported
29109	Lawrence	Missouri	Established	Reported
29113	Lincoln	Missouri	Established	Reported
29179	Reynolds	Missouri	Established	Reported
29185	St Clair	Missouri	Established	Reported
29203	Shannon	Missouri	Established	Reported
29207	Stoddard	Missouri	Established	Reported
29209	Stone	Missouri	Established	Reported
29219	Warren	Missouri	Established	Reported
29221	Washington	Missouri	Established	Reported
29223	Wayne	Missouri	Established	Reported
29225	Webster	Missouri	Established	Reported
36009	Cattaraugus	New York	Established	Reported
36013	Chautauqua	New York	Established	Reported
36029	Erie	New York	Established	Reported
36055	Monroe	New York	Established	Reported
36091	Saratoga	New York	Established	Reported
36093	Schenectady	New York	Established	Reported
36105	Sullivan	New York	Established	Reported
36111	Ulster	New York	Established	Reported
36113	Warren	New York	Established	Reported
37013	Beaufort	North Carolina	Established	Reported
37041	Chowan	North Carolina	Established	Reported
37051	Cumberland	North Carolina	Established	Reported
37103	Jones	North Carolina	Established	Reported
37105	Lee	North Carolina	Established	Reported
37129	New Hanover	North Carolina	Established	Reported
37131	Northampton	North Carolina	Established	Reported
37141	Pender	North Carolina	Established	Reported
37167	Stanly	North Carolina	Established	Reported

FIPS	County	State	Springer et al. 2014 County Status for *A. americanum*	TickSpotters (2014-2019) County Status for *A. americanum*
40001	Adair	Oklahoma	Established	Reported
40019	Carter	Oklahoma	Established	Reported
40021	Cherokee	Oklahoma	Established	Reported
40023	Choctaw	Oklahoma	Established	Reported
40069	Johnston	Oklahoma	Established	Reported
40077	Latimer	Oklahoma	Established	Reported
40101	Muskogee	Oklahoma	Established	Reported
40113	Osage	Oklahoma	Established	Reported
40119	Payne	Oklahoma	Established	Reported
45015	Berkeley	South Carolina	Established	Reported
45025	Chesterfield	South Carolina	Established	Reported
45029	Colleton	South Carolina	Established	Reported
45037	Edgefield	South Carolina	Established	Reported
45043	Georgetown	South Carolina	Established	Reported
45085	Sumter	South Carolina	Established	Reported
45089	Williamsburg	South Carolina	Established	Reported
47015	Cannon	Tennessee	Established	Reported
47031	Coffee	Tennessee	Established	Reported
47047	Fayette	Tennessee	Established	Reported
47051	Franklin	Tennessee	Established	Reported
47055	Giles	Tennessee	Established	Reported
47071	Hardin	Tennessee	Established	Reported
47075	Haywood	Tennessee	Established	Reported
47077	Henderson	Tennessee	Established	Reported
47079	Henry	Tennessee	Established	Reported
47085	Humphreys	Tennessee	Established	Reported
47103	Lincoln	Tennessee	Established	Reported
47113	Madison	Tennessee	Established	Reported
47115	Marion	Tennessee	Established	Reported
47145	Roane	Tennessee	Established	Reported
47147	Robertson	Tennessee	Established	Reported
47151	Scott	Tennessee	Established	Reported
47155	Sevier	Tennessee	Established	Reported
47159	Smith	Tennessee	Established	Reported
47161	Stewart	Tennessee	Established	Reported
47173	Union	Tennessee	Established	Reported
48001	Anderson	Texas	Established	Reported

FIPS	County	State	Springer et al. 2014 County Status for *A. americanum*	TickSpotters (2014-2019) County Status for *A. americanum*
48029	Bexar	Texas	Established	Reported
48037	Bowie	Texas	Established	Reported
48073	Cherokee	Texas	Established	Reported
48099	Coryell	Texas	Established	Reported
48137	Edwards	Texas	Established	Reported
48171	Gillespie	Texas	Established	Reported
48181	Grayson	Texas	Established	Reported
48203	Harrison	Texas	Established	Reported
48213	Henderson	Texas	Established	Reported
48231	Hunt	Texas	Established	Reported
48251	Johnson	Texas	Established	Reported
48257	Kaufman	Texas	Established	Reported
48265	Kerr	Texas	Established	Reported
48267	Kimble	Texas	Established	Reported
48281	Lampasas	Texas	Established	Reported
48289	Leon	Texas	Established	Reported
48309	Mclennan	Texas	Established	Reported
48339	Montgomery	Texas	Established	Reported
48349	Navarro	Texas	Established	Reported
48367	Parker	Texas	Established	Reported
48373	Polk	Texas	Established	Reported
48385	Real	Texas	Established	Reported
48387	Red River	Texas	Established	Reported
48423	Smith	Texas	Established	Reported
48427	Starr	Texas	Established	Reported
48435	Sutton	Texas	Established	Reported
48457	Tyler	Texas	Established	Reported
48463	Uvalde	Texas	Established	Reported
48465	Val Verde	Texas	Established	Reported
48467	Van Zandt	Texas	Established	Reported
48471	Walker	Texas	Established	Reported
48491	Williamson	Texas	Established	Reported
48499	Wood	Texas	Established	Reported
05005	Baxter	Arkansas	Established	Reported
05009	Boone	Arkansas	Established	Reported
05015	Carroll	Arkansas	Established	Reported
05023	Cleburne	Arkansas	Established	Reported

FIPS	County	State	Springer et al. 2014 County Status for *A. americanum*	TickSpotters (2014-2019) County Status for *A. americanum*
05027	Columbia	Arkansas	Established	Reported
05029	Conway	Arkansas	Established	Reported
05033	Crawford	Arkansas	Established	Reported
05041	Desha	Arkansas	Established	Reported
05045	Faulkner	Arkansas	Established	Reported
05055	Greene	Arkansas	Established	Reported
05059	Hot Spring	Arkansas	Established	Reported
05063	Independence	Arkansas	Established	Reported
05069	Jefferson	Arkansas	Established	Reported
05075	Lawrence	Arkansas	Established	Reported
05087	Madison	Arkansas	Established	Reported
05089	Marion	Arkansas	Established	Reported
05097	Montgomery	Arkansas	Established	Reported
51001	Accomack:chincoteague	Virginia	Established	Reported
51001	Accomack:chincoteague	Virginia	Established	Reported
51001	Accomack:main	Virginia	Established	Reported
51001	Accomack:main	Virginia	Established	Reported
51007	Amelia	Virginia	Established	Reported
05101	Newton	Arkansas	Established	Reported
51011	Appomattox	Virginia	Established	Reported
51025	Brunswick	Virginia	Established	Reported
51033	Caroline	Virginia	Established	Reported
05109	Pike	Arkansas	Established	Reported
51097	King And Queen	Virginia	Established	Reported
51127	New Kent	Virginia	Established	Reported
05113	Polk	Arkansas	Established	Reported
51145	Powhatan	Virginia	Established	Reported
05115	Pope	Arkansas	Established	Reported
05129	Searcy	Arkansas	Established	Reported
05131	Sebastian	Arkansas	Established	Reported
05133	Sevier	Arkansas	Established	Reported
05149	Yell	Arkansas	Established	Reported
01127	Walker	Alabama	No record	Established
12011	Broward	Florida	No record	Established
13139	Hall	Georgia	No record	Established
17089	Kane	Illinois	No record	Established
18057	Hamilton	Indiana	No record	Established

FIPS	County	State	Springer et al. 2014 County Status for *A. americanum*	TickSpotters (2014-2019) County Status for *A. americanum*
20035	Cowley	Kansas	No record	Established
20173	Sedgwick	Kansas	No record	Established
21067	Fayette	Kentucky	No record	Established
21103	Henry	Kentucky	No record	Established
21185	Oldham	Kentucky	No record	Established
22103	St Tammany	Louisiana	No record	Established
24013	Carroll	Maryland	No record	Established
24027	Howard	Maryland	No record	Established
24510	Baltimore City	Maryland	No record	Established
25001	Barnstable	Massachusetts	No record	Established
31159	Seward	Nebraska	No record	Established
34003	Bergen	New Jersey	No record	Established
34015	Gloucester	New Jersey	No record	Established
34023	Middlesex	New Jersey	No record	Established
34027	Morris	New Jersey	No record	Established
34039	Union	New Jersey	No record	Established
36047	Kings	New York	No record	Established
36061	New York	New York	No record	Established
37025	Cabarrus	North Carolina	No record	Established
37067	Forsyth	North Carolina	No record	Established
37081	Guilford	North Carolina	No record	Established
37119	Mecklenburg	North Carolina	No record	Established
37157	Rockingham	North Carolina	No record	Established
37169	Stokes	North Carolina	No record	Established
39049	Franklin	Ohio	No record	Established
40027	Cleveland	Oklahoma	No record	Established
40131	Rogers	Oklahoma	No record	Established
40147	Washington	Oklahoma	No record	Established
42017	Bucks	Pennsylvania	No record	Established
42091	Montgomery	Pennsylvania	No record	Established
42101	Philadelphia	Pennsylvania	No record	Established
45035	Dorchester	South Carolina	No record	Established
47011	Bradley	Tennessee	No record	Established
47105	Loudon	Tennessee	No record	Established
47119	Maury	Tennessee	No record	Established
51009	Amherst	Virginia	No record	Established
51019	Bedford	Virginia	No record	Established

FIPS	County	State	Springer et al. 2014 County Status for *A. americanum*	TickSpotters (2014-2019) County Status for *A. americanum*
51043	Clarke	Virginia	No record	Established
51067	Franklin	Virginia	No record	Established
51069	Frederick	Virginia	No record	Established
51093	Isle Of Wight	Virginia	No record	Established
51139	Page	Virginia	No record	Established
51161	Roanoke	Virginia	No record	Established
51163	Rockbridge	Virginia	No record	Established
51165	Rockingham	Virginia	No record	Established
51187	Warren	Virginia	No record	Established
54011	Cabell	West Virginia	No record	Established
54079	Putnam	West Virginia	No record	Established
01001	Autauga	Alabama	No record	Reported
01019	Cherokee	Alabama	No record	Reported
01035	Conecuh	Alabama	No record	Reported
01055	Etowah	Alabama	No record	Reported
12015	Charlotte	Florida	No record	Reported
12021	Collier	Florida	No record	Reported
12071	Lee	Florida	No record	Reported
12111	St Lucie	Florida	No record	Reported
12125	Union	Florida	No record	Reported
13009	Baldwin	Georgia	No record	Reported
13043	Candler	Georgia	No record	Reported
13097	Douglas	Georgia	No record	Reported
13137	Habersham	Georgia	No record	Reported
13167	Johnson	Georgia	No record	Reported
13227	Pickens	Georgia	No record	Reported
13233	Polk	Georgia	No record	Reported
13281	Towns	Georgia	No record	Reported
13311	White	Georgia	No record	Reported
16035	Clearwater	Idaho	No record	Reported
17001	Adams	Illinois	No record	Reported
17007	Boone	Illinois	No record	Reported
17015	Carroll	Illinois	No record	Reported
17017	Cass	Illinois	No record	Reported
17019	Champaign	Illinois	No record	Reported
17037	De Kalb	Illinois	No record	Reported
17053	Ford	Illinois	No record	Reported

FIPS	County	State	Springer et al. 2014 County Status for *A. americanum*	TickSpotters (2014-2019) County Status for *A. americanum*
17055	Franklin	Illinois	No record	Reported
17059	Gallatin	Illinois	No record	Reported
17063	Grundy	Illinois	No record	Reported
17071	Henderson	Illinois	No record	Reported
17073	Henry	Illinois	No record	Reported
17081	Jefferson	Illinois	No record	Reported
17083	Jersey	Illinois	No record	Reported
17091	Kankakee	Illinois	No record	Reported
17093	Kendall	Illinois	No record	Reported
17103	Lee	Illinois	No record	Reported
17105	Livingston	Illinois	No record	Reported
17113	Mclean	Illinois	No record	Reported
17115	Macon	Illinois	No record	Reported
17117	Macoupin	Illinois	No record	Reported
17119	Madison	Illinois	No record	Reported
17121	Marion	Illinois	No record	Reported
17125	Mason	Illinois	No record	Reported
17133	Monroe	Illinois	No record	Reported
17135	Montgomery	Illinois	No record	Reported
17141	Ogle	Illinois	No record	Reported
17143	Peoria	Illinois	No record	Reported
17147	Piatt	Illinois	No record	Reported
17163	St Clair	Illinois	No record	Reported
17165	Saline	Illinois	No record	Reported
17167	Sangamon	Illinois	No record	Reported
17191	Wayne	Illinois	No record	Reported
17197	Will	Illinois	No record	Reported
17201	Winnebago	Illinois	No record	Reported
18003	Allen	Indiana	No record	Reported
18005	Bartholomew	Indiana	No record	Reported
18029	Dearborn	Indiana	No record	Reported
18035	Delaware	Indiana	No record	Reported
18039	Elkhart	Indiana	No record	Reported
18047	Franklin	Indiana	No record	Reported
18063	Hendricks	Indiana	No record	Reported
18071	Jackson	Indiana	No record	Reported
18073	Jasper	Indiana	No record	Reported

FIPS	County	State	Springer et al. 2014 County Status for *A. americanum*	TickSpotters (2014-2019) County Status for *A. americanum*
18077	Jefferson	Indiana	No record	Reported
18079	Jennings	Indiana	No record	Reported
18081	Johnson	Indiana	No record	Reported
18089	Lake	Indiana	No record	Reported
18091	La Porte	Indiana	No record	Reported
18109	Morgan	Indiana	No record	Reported
18119	Owen	Indiana	No record	Reported
18127	Porter	Indiana	No record	Reported
18137	Ripley	Indiana	No record	Reported
18143	Scott	Indiana	No record	Reported
18145	Shelby	Indiana	No record	Reported
18167	Vigo	Indiana	No record	Reported
19055	Delaware	Iowa	No record	Reported
19161	Sac	Iowa	No record	Reported
19171	Tama	Iowa	No record	Reported
20001	Allen	Kansas	No record	Reported
20005	Atchison	Kansas	No record	Reported
20009	Barton	Kansas	No record	Reported
20015	Butler	Kansas	No record	Reported
20049	Elk	Kansas	No record	Reported
20059	Franklin	Kansas	No record	Reported
20063	Gove	Kansas	No record	Reported
20079	Harvey	Kansas	No record	Reported
20127	Morris	Kansas	No record	Reported
20133	Neosho	Kansas	No record	Reported
20139	Osage	Kansas	No record	Reported
20141	Osborne	Kansas	No record	Reported
20155	Reno	Kansas	No record	Reported
20171	Scott	Kansas	No record	Reported
20177	Shawnee	Kansas	No record	Reported
20197	Wabaunsee	Kansas	No record	Reported
21005	Anderson	Kentucky	No record	Reported
21015	Boone	Kentucky	No record	Reported
21019	Boyd	Kentucky	No record	Reported
21021	Boyle	Kentucky	No record	Reported
21033	Caldwell	Kentucky	No record	Reported
21037	Campbell	Kentucky	No record	Reported

FIPS	County	State	Springer et al. 2014 County Status for *A. americanum*	TickSpotters (2014-2019) County Status for *A. americanum*
21043	Carter	Kentucky	No record	Reported
21057	Cumberland	Kentucky	No record	Reported
21071	Floyd	Kentucky	No record	Reported
21073	Franklin	Kentucky	No record	Reported
21077	Gallatin	Kentucky	No record	Reported
21081	Grant	Kentucky	No record	Reported
21085	Grayson	Kentucky	No record	Reported
21089	Greenup	Kentucky	No record	Reported
21099	Hart	Kentucky	No record	Reported
21101	Henderson	Kentucky	No record	Reported
21107	Hopkins	Kentucky	No record	Reported
21109	Jackson	Kentucky	No record	Reported
21113	Jessamine	Kentucky	No record	Reported
21115	Johnson	Kentucky	No record	Reported
21117	Kenton	Kentucky	No record	Reported
21119	Knott	Kentucky	No record	Reported
21123	Larue	Kentucky	No record	Reported
21125	Laurel	Kentucky	No record	Reported
21129	Lee	Kentucky	No record	Reported
21131	Leslie	Kentucky	No record	Reported
21133	Letcher	Kentucky	No record	Reported
21137	Lincoln	Kentucky	No record	Reported
21139	Livingston	Kentucky	No record	Reported
21149	Mclean	Kentucky	No record	Reported
21155	Marion	Kentucky	No record	Reported
21167	Mercer	Kentucky	No record	Reported
21171	Monroe	Kentucky	No record	Reported
21175	Morgan	Kentucky	No record	Reported
21187	Owen	Kentucky	No record	Reported
21189	Owsley	Kentucky	No record	Reported
21193	Perry	Kentucky	No record	Reported
21195	Pike	Kentucky	No record	Reported
21197	Powell	Kentucky	No record	Reported
21199	Pulaski	Kentucky	No record	Reported
21205	Rowan	Kentucky	No record	Reported
21207	Russell	Kentucky	No record	Reported
21209	Scott	Kentucky	No record	Reported

FIPS	County	State	Springer et al. 2014 County Status for *A. americanum*	TickSpotters (2014-2019) County Status for *A. americanum*
21211	Shelby	Kentucky	No record	Reported
21215	Spencer	Kentucky	No record	Reported
21235	Whitley	Kentucky	No record	Reported
21237	Wolfe	Kentucky	No record	Reported
21239	Woodford	Kentucky	No record	Reported
22017	Caddo	Louisiana	No record	Reported
22051	Jefferson	Louisiana	No record	Reported
22055	Lafayette	Louisiana	No record	Reported
22073	Ouachita	Louisiana	No record	Reported
22119	Webster	Louisiana	No record	Reported
23029	Washington	Maine	No record	Reported
24001	Allegany	Maryland	No record	Reported
24021	Frederick	Maryland	No record	Reported
24023	Garrett	Maryland	No record	Reported
24043	Washington	Maryland	No record	Reported
25005	Bristol	Massachusetts	No record	Reported
25009	Essex	Massachusetts	No record	Reported
25013	Hampden	Massachusetts	No record	Reported
25017	Middlesex	Massachusetts	No record	Reported
25019	Nantucket	Massachusetts	No record	Reported
25021	Norfolk	Massachusetts	No record	Reported
25023	Plymouth	Massachusetts	No record	Reported
26001	Alcona	Michigan	No record	Reported
26021	Berrien	Michigan	No record	Reported
26057	Gratiot	Michigan	No record	Reported
26119	Montmorency	Michigan	No record	Reported
27021	Cass	Minnesota	No record	Reported
27039	Dodge	Minnesota	No record	Reported
27053	Hennepin	Minnesota	No record	Reported
27077	Lake Of The Woods	Minnesota	No record	Reported
27121	Pope	Minnesota	No record	Reported
27123	Ramsey	Minnesota	No record	Reported
27131	Rice	Minnesota	No record	Reported
27137	St Louis	Minnesota	No record	Reported
28115	Pontotoc	Mississippi	No record	Reported
28145	Union	Mississippi	No record	Reported
29033	Carroll	Missouri	No record	Reported

FIPS	County	State	Springer et al. 2014 County Status for *A. americanum*	TickSpotters (2014-2019) County Status for *A. americanum*
29063	De Kalb	Missouri	No record	Reported
29111	Lewis	Missouri	No record	Reported
29115	Linn	Missouri	No record	Reported
29133	Mississippi	Missouri	No record	Reported
29139	Montgomery	Missouri	No record	Reported
29145	Newton	Missouri	No record	Reported
29165	Platte	Missouri	No record	Reported
29227	Worth	Missouri	No record	Reported
30013	Cascade	Montana	No record	Reported
31025	Cass	Nebraska	No record	Reported
31053	Dodge	Nebraska	No record	Reported
31055	Douglas	Nebraska	No record	Reported
31079	Hall	Nebraska	No record	Reported
31131	Otoe	Nebraska	No record	Reported
31177	Washington	Nebraska	No record	Reported
33003	Carroll	New Hampshire	No record	Reported
33005	Cheshire	New Hampshire	No record	Reported
33019	Sullivan	New Hampshire	No record	Reported
34013	Essex	New Jersey	No record	Reported
34017	Hudson	New Jersey	No record	Reported
34031	Passaic	New Jersey	No record	Reported
34035	Somerset	New Jersey	No record	Reported
34037	Sussex	New Jersey	No record	Reported
36067	Onondaga	New York	No record	Reported
36079	Putnam	New York	No record	Reported
36109	Tompkins	New York	No record	Reported
36117	Wayne	New York	No record	Reported
37021	Buncombe	North Carolina	No record	Reported
37023	Burke	North Carolina	No record	Reported
37029	Camden	North Carolina	No record	Reported
37035	Catawba	North Carolina	No record	Reported
37057	Davidson	North Carolina	No record	Reported
37059	Davie	North Carolina	No record	Reported
37091	Hertford	North Carolina	No record	Reported
37115	Madison	North Carolina	No record	Reported
37139	Pasquotank	North Carolina	No record	Reported
37145	Person	North Carolina	No record	Reported

FIPS	County	State	Springer et al. 2014 County Status for *A. americanum*	TickSpotters (2014-2019) County Status for *A. americanum*
37159	Rowan	North Carolina	No record	Reported
37161	Rutherford	North Carolina	No record	Reported
37165	Scotland	North Carolina	No record	Reported
37171	Surry	North Carolina	No record	Reported
37191	Wayne	North Carolina	No record	Reported
37193	Wilkes	North Carolina	No record	Reported
37195	Wilson	North Carolina	No record	Reported
38031	Foster	North Dakota	No record	Reported
39001	Adams	Ohio	No record	Reported
39005	Ashland	Ohio	No record	Reported
39009	Athens	Ohio	No record	Reported
39029	Columbiana	Ohio	No record	Reported
39055	Geauga	Ohio	No record	Reported
39057	Greene	Ohio	No record	Reported
39075	Holmes	Ohio	No record	Reported
39077	Huron	Ohio	No record	Reported
39087	Lawrence	Ohio	No record	Reported
39089	Licking	Ohio	No record	Reported
39095	Lucas	Ohio	No record	Reported
39103	Medina	Ohio	No record	Reported
39105	Meigs	Ohio	No record	Reported
39129	Pickaway	Ohio	No record	Reported
39133	Portage	Ohio	No record	Reported
39147	Seneca	Ohio	No record	Reported
39153	Summit	Ohio	No record	Reported
39165	Warren	Ohio	No record	Reported
39173	Wood	Ohio	No record	Reported
40017	Canadian	Oklahoma	No record	Reported
40037	Creek	Oklahoma	No record	Reported
40039	Custer	Oklahoma	No record	Reported
40051	Grady	Oklahoma	No record	Reported
40071	Kay	Oklahoma	No record	Reported
40083	Logan	Oklahoma	No record	Reported
40103	Noble	Oklahoma	No record	Reported
40115	Ottawa	Oklahoma	No record	Reported
40117	Pawnee	Oklahoma	No record	Reported
40133	Seminole	Oklahoma	No record	Reported

FIPS	County	State	Springer et al. 2014 County Status for *A. americanum*	TickSpotters (2014-2019) County Status for *A. americanum*
40145	Wagoner	Oklahoma	No record	Reported
41067	Washington	Oregon	No record	Reported
42001	Adams	Pennsylvania	No record	Reported
42003	Allegheny	Pennsylvania	No record	Reported
42005	Armstrong	Pennsylvania	No record	Reported
42011	Berks	Pennsylvania	No record	Reported
42015	Bradford	Pennsylvania	No record	Reported
42027	Centre	Pennsylvania	No record	Reported
42041	Cumberland	Pennsylvania	No record	Reported
42045	Delaware	Pennsylvania	No record	Reported
42049	Erie	Pennsylvania	No record	Reported
42055	Franklin	Pennsylvania	No record	Reported
42063	Indiana	Pennsylvania	No record	Reported
42069	Lackawanna	Pennsylvania	No record	Reported
42071	Lancaster	Pennsylvania	No record	Reported
42077	Lehigh	Pennsylvania	No record	Reported
42097	Northumberland	Pennsylvania	No record	Reported
42117	Tioga	Pennsylvania	No record	Reported
42125	Washington	Pennsylvania	No record	Reported
42129	Westmoreland	Pennsylvania	No record	Reported
44003	Kent	Rhode Island	No record	Reported
44007	Providence	Rhode Island	No record	Reported
45003	Aiken	South Carolina	No record	Reported
45017	Calhoun	South Carolina	No record	Reported
45031	Darlington	South Carolina	No record	Reported
45073	Oconee	South Carolina	No record	Reported
45091	York	South Carolina	No record	Reported
46127	Union	South Dakota	No record	Reported
47023	Chester	Tennessee	No record	Reported
47045	Dyer	Tennessee	No record	Reported
47053	Gibson	Tennessee	No record	Reported
47059	Greene	Tennessee	No record	Reported
47061	Grundy	Tennessee	No record	Reported
47063	Hamblen	Tennessee	No record	Reported
47111	Macon	Tennessee	No record	Reported
47131	Obion	Tennessee	No record	Reported
47133	Overton	Tennessee	No record	Reported

FIPS	County	State	Springer et al. 2014 County Status for *A. americanum*	TickSpotters (2014-2019) County Status for *A. americanum*
47179	Washington	Tennessee	No record	Reported
48071	Chambers	Texas	No record	Reported
48135	Ector	Texas	No record	Reported
48315	Marion	Texas	No record	Reported
48355	Nueces	Texas	No record	Reported
48489	Willacy	Texas	No record	Reported
49011	Davis	Utah	No record	Reported
50007	Chittenden	Vermont	No record	Reported
05031	Craighead	Arkansas	No record	Reported
05085	Lonoke	Arkansas	No record	Reported
05093	Mississippi	Arkansas	No record	Reported
51065	Fluvanna	Virginia	No record	Reported
51079	Greene	Virginia	No record	Reported
51083	Halifax	Virginia	No record	Reported
51089	Henry	Virginia	No record	Reported
51103	Lancaster	Virginia	No record	Reported
05111	Poinsett	Arkansas	No record	Reported
51113	Madison	Virginia	No record	Reported
51115	Mathews	Virginia	No record	Reported
51117	Mecklenburg	Virginia	No record	Reported
51119	Middlesex	Virginia	No record	Reported
51125	Nelson	Virginia	No record	Reported
51133	Northumberland	Virginia	No record	Reported
51143	Pittsylvania	Virginia	No record	Reported
51147	Prince Edward	Virginia	No record	Reported
51157	Rappahannock	Virginia	No record	Reported
51171	Shenandoah	Virginia	No record	Reported
51191	Washington	Virginia	No record	Reported
54003	Berkeley	West Virginia	No record	Reported
54005	Boone	West Virginia	No record	Reported
54025	Greenbrier	West Virginia	No record	Reported
54035	Jackson	West Virginia	No record	Reported
54037	Jefferson	West Virginia	No record	Reported
54039	Kanawha	West Virginia	No record	Reported
54043	Lincoln	West Virginia	No record	Reported
54049	Marion	West Virginia	No record	Reported
54053	Mason	West Virginia	No record	Reported

FIPS	County	State	Springer et al. 2014 County Status for *A. americanum*	TickSpotters (2014-2019) County Status for *A. americanum*
54061	Monongalia	West Virginia	No record	Reported
54093	Tucker	West Virginia	No record	Reported
54099	Wayne	West Virginia	No record	Reported
55003	Ashland	Wisconsin	No record	Reported
55005	Barron	Wisconsin	No record	Reported
55025	Dane	Wisconsin	No record	Reported
55027	Dodge	Wisconsin	No record	Reported
55029	Door	Wisconsin	No record	Reported
55039	Fond Du Lac	Wisconsin	No record	Reported
55051	Iron	Wisconsin	No record	Reported
55063	La Crosse	Wisconsin	No record	Reported
55079	Milwaukee	Wisconsin	No record	Reported
55081	Monroe	Wisconsin	No record	Reported
55125	Vilas	Wisconsin	No record	Reported
55133	Waukesha	Wisconsin	No record	Reported
06001	Alameda	California	No record	Reported
06037	Los Angeles	California	No record	Reported
06041	Marin	California	No record	Reported
06045	Mendocino	California	No record	Reported
06059	Orange	California	No record	Reported
06083	Santa Barbara	California	No record	Reported
08013	Boulder	Colorado	No record	Reported
08035	Douglas	Colorado	No record	Reported
08059	Jefferson	Colorado	No record	Reported
08069	Larimer	Colorado	No record	Reported
09003	Hartford	Connecticut	No record	Reported
09005	Litchfield	Connecticut	No record	Reported
09007	Middlesex	Connecticut	No record	Reported
09011	New London	Connecticut	No record	Reported
09013	Tolland	Connecticut	No record	Reported
10001	Kent	Delaware	Reported	Established
10003	New Castle	Delaware	Reported	Established
10005	Sussex	Delaware	Reported	Established
01043	Cullman	Alabama	Reported	Established
01073	Jefferson	Alabama	Reported	Established
11001	Washington	District Of Columbia	Reported	Established
01103	Morgan	Alabama	Reported	Established

FIPS	County	State	Springer et al. 2014 County Status for *A. americanum*	TickSpotters (2014-2019) County Status for *A. americanum*
01125	Tuscaloosa	Alabama	Reported	Established
12001	Alachua	Florida	Reported	Established
12017	Citrus	Florida	Reported	Established
12031	Duval	Florida	Reported	Established
12035	Flagler	Florida	Reported	Established
12057	Hillsborough	Florida	Reported	Established
12069	Lake	Florida	Reported	Established
12073	Leon	Florida	Reported	Established
12083	Marion	Florida	Reported	Established
12091	Okaloosa:main	Florida	Reported	Established
12091	Okaloosa:main	Florida	Reported	Established
12091	Okaloosa:spit	Florida	Reported	Established
12091	Okaloosa:spit	Florida	Reported	Established
12117	Seminole	Florida	Reported	Established
12127	Volusia	Florida	Reported	Established
12129	Wakulla	Florida	Reported	Established
13021	Bibb	Georgia	Reported	Established
13045	Carroll	Georgia	Reported	Established
13051	Chatham	Georgia	Reported	Established
13059	Clarke	Georgia	Reported	Established
13063	Clayton	Georgia	Reported	Established
13067	Cobb	Georgia	Reported	Established
13073	Columbia	Georgia	Reported	Established
13077	Coweta	Georgia	Reported	Established
13089	De Kalb	Georgia	Reported	Established
13113	Fayette	Georgia	Reported	Established
13117	Forsyth	Georgia	Reported	Established
13121	Fulton	Georgia	Reported	Established
13135	Gwinnett	Georgia	Reported	Established
13151	Henry	Georgia	Reported	Established
13153	Houston	Georgia	Reported	Established
13157	Jackson	Georgia	Reported	Established
13215	Muscogee	Georgia	Reported	Established
13217	Newton	Georgia	Reported	Established
13297	Walton	Georgia	Reported	Established
17031	Cook	Illinois	Reported	Established
17043	Du Page	Illinois	Reported	Established

FIPS	County	State	Springer et al. 2014 County Status for *A. americanum*	TickSpotters (2014-2019) County Status for *A. americanum*
18013	Brown	Indiana	Reported	Established
18019	Clark	Indiana	Reported	Established
18097	Marion	Indiana	Reported	Established
18105	Monroe	Indiana	Reported	Established
18163	Vanderburgh	Indiana	Reported	Established
19153	Polk	Iowa	Reported	Established
20091	Johnson	Kansas	Reported	Established
20103	Leavenworth	Kansas	Reported	Established
21009	Barren	Kentucky	Reported	Established
21061	Edmonson	Kentucky	Reported	Established
21221	Trigg	Kentucky	Reported	Established
21227	Warren	Kentucky	Reported	Established
24003	Anne Arundel	Maryland	Reported	Established
24005	Baltimore	Maryland	Reported	Established
24009	Calvert	Maryland	Reported	Established
24031	Montgomery	Maryland	Reported	Established
24033	Prince Georges	Maryland	Reported	Established
24041	Talbot	Maryland	Reported	Established
24047	Worcester	Maryland	Reported	Established
25007	Dukes	Massachusetts	Reported	Established
29019	Boone	Missouri	Reported	Established
29029	Camden	Missouri	Reported	Established
29071	Franklin	Missouri	Reported	Established
29077	Greene	Missouri	Reported	Established
29095	Jackson	Missouri	Reported	Established
29169	Pulaski	Missouri	Reported	Established
29189	St Louis	Missouri	Reported	Established
34001	Atlantic	New Jersey	Reported	Established
34007	Camden	New Jersey	Reported	Established
34009	Cape May	New Jersey	Reported	Established
34021	Mercer	New Jersey	Reported	Established
34029	Ocean	New Jersey	Reported	Established
34033	Salem	New Jersey	Reported	Established
36081	Queens	New York	Reported	Established
36085	Richmond	New York	Reported	Established
36103	Suffolk	New York	Reported	Established
36119	Westchester	New York	Reported	Established

FIPS	County	State	Springer et al. 2014 County Status for *A. americanum*	TickSpotters (2014-2019) County Status for *A. americanum*
37019	Brunswick	North Carolina	Reported	Established
37049	Craven	North Carolina	Reported	Established
37063	Durham	North Carolina	Reported	Established
37069	Franklin	North Carolina	Reported	Established
37077	Granville	North Carolina	Reported	Established
37085	Harnett	North Carolina	Reported	Established
37101	Johnston	North Carolina	Reported	Established
37125	Moore	North Carolina	Reported	Established
37133	Onslow	North Carolina	Reported	Established
37135	Orange	North Carolina	Reported	Established
37181	Vance	North Carolina	Reported	Established
37183	Wake	North Carolina	Reported	Established
39061	Hamilton	Ohio	Reported	Established
40089	Mccurtain	Oklahoma	Reported	Established
40109	Oklahoma	Oklahoma	Reported	Established
40143	Tulsa	Oklahoma	Reported	Established
42029	Chester	Pennsylvania	Reported	Established
45013	Beaufort	South Carolina	Reported	Established
45019	Charleston	South Carolina	Reported	Established
45045	Greenville	South Carolina	Reported	Established
45051	Horry	South Carolina	Reported	Established
45063	Lexington	South Carolina	Reported	Established
45079	Richland	South Carolina	Reported	Established
45083	Spartanburg	South Carolina	Reported	Established
47035	Cumberland	Tennessee	Reported	Established
47037	Davidson	Tennessee	Reported	Established
47093	Knox	Tennessee	Reported	Established
47125	Montgomery	Tennessee	Reported	Established
47149	Rutherford	Tennessee	Reported	Established
47187	Williamson	Tennessee	Reported	Established
47189	Wilson	Tennessee	Reported	Established
48113	Dallas	Texas	Reported	Established
48121	Denton	Texas	Reported	Established
48201	Harris	Texas	Reported	Established
48215	Hidalgo	Texas	Reported	Established
48347	Nacogdoches	Texas	Reported	Established
48453	Travis	Texas	Reported	Established

FIPS	County	State	Springer et al. 2014 County Status for *A. americanum*	TickSpotters (2014-2019) County Status for *A. americanum*
05007	Benton	Arkansas	Reported	Established
05051	Garland	Arkansas	Reported	Established
51003	Albemarle	Virginia	Reported	Established
51013	Arlington	Virginia	Reported	Established
51031	Campbell	Virginia	Reported	Established
51041	Chesterfield	Virginia	Reported	Established
51047	Culpeper	Virginia	Reported	Established
51059	Fairfax	Virginia	Reported	Established
51061	Fauquier	Virginia	Reported	Established
51073	Gloucester	Virginia	Reported	Established
51075	Goochland	Virginia	Reported	Established
51085	Hanover	Virginia	Reported	Established
51087	Henrico	Virginia	Reported	Established
51095	James City	Virginia	Reported	Established
51099	King George	Virginia	Reported	Established
51107	Loudoun	Virginia	Reported	Established
51109	Louisa	Virginia	Reported	Established
51131	Northampton	Virginia	Reported	Established
51137	Orange	Virginia	Reported	Established
51153	Prince William	Virginia	Reported	Established
51177	Spotsylvania	Virginia	Reported	Established
51179	Stafford	Virginia	Reported	Established
05119	Pulaski	Arkansas	Reported	Established
51199	York	Virginia	Reported	Established
05125	Saline	Arkansas	Reported	Established
05143	Washington	Arkansas	Reported	Established
51650	Hampton	Virginia	Reported	Established
51700	Newport News	Virginia	Reported	Established
51800	Suffolk	Virginia	Reported	Established
51810	Virginia Beach	Virginia	Reported	Established
09001	Fairfield	Connecticut	Reported	Established
09009	New Haven	Connecticut	Reported	Established
01005	Barbour	Alabama	Reported	No record
01007	Bibb	Alabama	Reported	No record
01011	Bullock	Alabama	Reported	No record
01021	Chilton	Alabama	Reported	No record
01023	Choctaw	Alabama	Reported	No record

FIPS	County	State	Springer et al. 2014 County Status for *A. americanum*	TickSpotters (2014-2019) County Status for *A. americanum*
01025	Clarke	Alabama	Reported	No record
01027	Clay	Alabama	Reported	No record
01031	Coffee	Alabama	Reported	No record
01033	Colbert	Alabama	Reported	No record
01037	Coosa	Alabama	Reported	No record
01039	Covington	Alabama	Reported	No record
01045	Dale	Alabama	Reported	No record
01047	Dallas	Alabama	Reported	No record
01053	Escambia	Alabama	Reported	No record
01059	Franklin	Alabama	Reported	No record
01063	Greene	Alabama	Reported	No record
01067	Henry	Alabama	Reported	No record
01085	Lowndes	Alabama	Reported	No record
01087	Macon	Alabama	Reported	No record
01091	Marengo	Alabama	Reported	No record
01099	Monroe	Alabama	Reported	No record
01105	Perry	Alabama	Reported	No record
01107	Pickens	Alabama	Reported	No record
01115	St Clair	Alabama	Reported	No record
01129	Washington	Alabama	Reported	No record
12013	Calhoun	Florida	Reported	No record
12033	Escambia	Florida	Reported	No record
12049	Hardee	Florida	Reported	No record
12055	Highlands	Florida	Reported	No record
12067	Lafayette	Florida	Reported	No record
12077	Liberty	Florida	Reported	No record
12079	Madison	Florida	Reported	No record
13001	Appling	Georgia	Reported	No record
13011	Banks	Georgia	Reported	No record
13015	Bartow	Georgia	Reported	No record
13017	Ben Hill	Georgia	Reported	No record
13023	Bleckley	Georgia	Reported	No record
13027	Brooks	Georgia	Reported	No record
13047	Catoosa	Georgia	Reported	No record
13049	Charlton	Georgia	Reported	No record
13055	Chattooga	Georgia	Reported	No record
13065	Clinch	Georgia	Reported	No record

FIPS	County	State	Springer et al. 2014 County Status for *A. americanum*	TickSpotters (2014-2019) County Status for *A. americanum*
13075	Cook	Georgia	Reported	No record
13079	Crawford	Georgia	Reported	No record
13087	Decatur	Georgia	Reported	No record
13101	Echols	Georgia	Reported	No record
13105	Elbert	Georgia	Reported	No record
13107	Emanuel	Georgia	Reported	No record
13109	Evans	Georgia	Reported	No record
13119	Franklin	Georgia	Reported	No record
13125	Glascock	Georgia	Reported	No record
13131	Grady	Georgia	Reported	No record
13141	Hancock	Georgia	Reported	No record
13155	Irwin	Georgia	Reported	No record
13161	Jeff Davis	Georgia	Reported	No record
13179	Liberty	Georgia	Reported	No record
13191	Mcintosh	Georgia	Reported	No record
13197	Marion	Georgia	Reported	No record
13207	Monroe	Georgia	Reported	No record
13213	Murray	Georgia	Reported	No record
13229	Pierce	Georgia	Reported	No record
13231	Pike	Georgia	Reported	No record
13235	Pulaski	Georgia	Reported	No record
13249	Schley	Georgia	Reported	No record
13255	Spalding	Georgia	Reported	No record
13257	Stephens	Georgia	Reported	No record
13263	Talbot	Georgia	Reported	No record
13265	Taliaferro	Georgia	Reported	No record
13267	Tattnall	Georgia	Reported	No record
13269	Taylor	Georgia	Reported	No record
13271	Telfair	Georgia	Reported	No record
13287	Turner	Georgia	Reported	No record
13299	Ware	Georgia	Reported	No record
13303	Washington	Georgia	Reported	No record
13313	Whitfield	Georgia	Reported	No record
17181	Union	Illinois	Reported	No record
18015	Carroll	Indiana	Reported	No record
18025	Crawford	Indiana	Reported	No record
18059	Hancock	Indiana	Reported	No record

FIPS	County	State	Springer et al. 2014 County Status for *A. americanum*	TickSpotters (2014-2019) County Status for *A. americanum*
18157	Tippecanoe	Indiana	Reported	No record
18175	Washington	Indiana	Reported	No record
19001	Adair	Iowa	Reported	No record
19011	Benton	Iowa	Reported	No record
19027	Carroll	Iowa	Reported	No record
19029	Cass	Iowa	Reported	No record
19039	Clarke	Iowa	Reported	No record
19045	Clinton	Iowa	Reported	No record
19047	Crawford	Iowa	Reported	No record
19057	Des Moines	Iowa	Reported	No record
19065	Fayette	Iowa	Reported	No record
19079	Hamilton	Iowa	Reported	No record
19081	Hancock	Iowa	Reported	No record
19083	Hardin	Iowa	Reported	No record
19097	Jackson	Iowa	Reported	No record
19099	Jasper	Iowa	Reported	No record
19121	Madison	Iowa	Reported	No record
19129	Mills	Iowa	Reported	No record
19149	Plymouth	Iowa	Reported	No record
19157	Poweshiek	Iowa	Reported	No record
19159	Ringgold	Iowa	Reported	No record
19165	Shelby	Iowa	Reported	No record
19167	Sioux	Iowa	Reported	No record
19173	Taylor	Iowa	Reported	No record
19183	Washington	Iowa	Reported	No record
19185	Wayne	Iowa	Reported	No record
19187	Webster	Iowa	Reported	No record
19191	Winneshiek	Iowa	Reported	No record
19193	Woodbury	Iowa	Reported	No record
19197	Wright	Iowa	Reported	No record
20031	Coffey	Kansas	Reported	No record
20055	Finney	Kansas	Reported	No record
20085	Jackson	Kansas	Reported	No record
20109	Logan	Kansas	Reported	No record
20125	Montgomery	Kansas	Reported	No record
20131	Nemaha	Kansas	Reported	No record
20191	Sumner	Kansas	Reported	No record

FIPS	County	State	Springer et al. 2014 County Status for *A. americanum*	TickSpotters (2014-2019) County Status for *A. americanum*
21007	Ballard	Kentucky	Reported	No record
21083	Graves	Kentucky	Reported	No record
22003	Allen	Louisiana	Reported	No record
22023	Cameron	Louisiana	Reported	No record
22043	Grant	Louisiana	Reported	No record
22049	Jackson	Louisiana	Reported	No record
22069	Natchitoches	Louisiana	Reported	No record
22079	Rapides	Louisiana	Reported	No record
22107	Tensas	Louisiana	Reported	No record
22111	Union	Louisiana	Reported	No record
22127	Winn	Louisiana	Reported	No record
23001	Androscoggin	Maine	Reported	No record
23015	Lincoln	Maine	Reported	No record
23017	Oxford	Maine	Reported	No record
23023	Sagadahoc	Maine	Reported	No record
23031	York	Maine	Reported	No record
25027	Worcester	Massachusetts	Reported	No record
26005	Allegan	Michigan	Reported	No record
26007	Alpena	Michigan	Reported	No record
26017	Bay	Michigan	Reported	No record
26033	Chippewa	Michigan	Reported	No record
26035	Clare	Michigan	Reported	No record
26037	Clinton	Michigan	Reported	No record
26039	Crawford	Michigan	Reported	No record
26041	Delta	Michigan	Reported	No record
26047	Emmet	Michigan	Reported	No record
26063	Huron	Michigan	Reported	No record
26065	Ingham	Michigan	Reported	No record
26069	Iosco	Michigan	Reported	No record
26073	Isabella	Michigan	Reported	No record
26075	Jackson	Michigan	Reported	No record
26091	Lenawee	Michigan	Reported	No record
26093	Livingston	Michigan	Reported	No record
26099	Macomb	Michigan	Reported	No record
26103	Marquette	Michigan	Reported	No record
26105	Mason	Michigan	Reported	No record
26111	Midland	Michigan	Reported	No record

FIPS	County	State	Springer et al. 2014 County Status for *A. americanum*	TickSpotters (2014-2019) County Status for *A. americanum*
26123	Newaygo	Michigan	Reported	No record
26127	Oceana	Michigan	Reported	No record
26131	Ontonagon	Michigan	Reported	No record
26145	Saginaw	Michigan	Reported	No record
26151	Sanilac	Michigan	Reported	No record
26155	Shiawassee	Michigan	Reported	No record
26157	Tuscola	Michigan	Reported	No record
26161	Washtenaw	Michigan	Reported	No record
27169	Winona	Minnesota	Reported	No record
28005	Amite	Mississippi	Reported	No record
28009	Benton	Mississippi	Reported	No record
28011	Bolivar	Mississippi	Reported	No record
28013	Calhoun	Mississippi	Reported	No record
28015	Carroll	Mississippi	Reported	No record
28017	Chickasaw	Mississippi	Reported	No record
28019	Choctaw	Mississippi	Reported	No record
28029	Copiah	Mississippi	Reported	No record
28031	Covington	Mississippi	Reported	No record
28035	Forrest	Mississippi	Reported	No record
28037	Franklin	Mississippi	Reported	No record
28039	George	Mississippi	Reported	No record
28047	Harrison	Mississippi	Reported	No record
28049	Hinds	Mississippi	Reported	No record
28057	Itawamba	Mississippi	Reported	No record
28059	Jackson	Mississippi	Reported	No record
28061	Jasper	Mississippi	Reported	No record
28065	Jefferson Davis	Mississippi	Reported	No record
28067	Jones	Mississippi	Reported	No record
28073	Lamar	Mississippi	Reported	No record
28077	Lawrence	Mississippi	Reported	No record
28085	Lincoln	Mississippi	Reported	No record
28093	Marshall	Mississippi	Reported	No record
28095	Monroe	Mississippi	Reported	No record
28101	Newton	Mississippi	Reported	No record
28103	Noxubee	Mississippi	Reported	No record
28107	Panola	Mississippi	Reported	No record
28111	Perry	Mississippi	Reported	No record

FIPS	County	State	Springer et al. 2014 County Status for *A. americanum*	TickSpotters (2014-2019) County Status for *A. americanum*
28123	Scott	Mississippi	Reported	No record
28129	Smith	Mississippi	Reported	No record
28131	Stone	Mississippi	Reported	No record
28141	Tishomingo	Mississippi	Reported	No record
28143	Tunica	Mississippi	Reported	No record
28147	Walthall	Mississippi	Reported	No record
28153	Wayne	Mississippi	Reported	No record
28155	Webster	Mississippi	Reported	No record
28159	Winston	Mississippi	Reported	No record
28163	Yazoo	Mississippi	Reported	No record
29011	Barton	Missouri	Reported	No record
29013	Bates	Missouri	Reported	No record
29023	Butler	Missouri	Reported	No record
29067	Douglas	Missouri	Reported	No record
29089	Howard	Missouri	Reported	No record
29105	Laclede	Missouri	Reported	No record
29157	Perry	Missouri	Reported	No record
29173	Ralls	Missouri	Reported	No record
35001	Bernalillo	New Mexico	Reported	No record
36005	Bronx	New York	Reported	No record
36015	Chemung	New York	Reported	No record
36017	Chenango	New York	Reported	No record
36019	Clinton	New York	Reported	No record
36031	Essex	New York	Reported	No record
36041	Hamilton	New York	Reported	No record
36043	Herkimer	New York	Reported	No record
36045	Jefferson	New York	Reported	No record
36053	Madison	New York	Reported	No record
36057	Montgomery	New York	Reported	No record
36063	Niagara	New York	Reported	No record
36069	Ontario	New York	Reported	No record
36071	Orange	New York	Reported	No record
36075	Oswego	New York	Reported	No record
36089	St Lawrence	New York	Reported	No record
36095	Schoharie	New York	Reported	No record
36097	Schuyler	New York	Reported	No record
36101	Steuben	New York	Reported	No record

FIPS	County	State	Springer et al. 2014 County Status for *A. americanum*	TickSpotters (2014-2019) County Status for *A. americanum*
36107	Tioga	New York	Reported	No record
36121	Wyoming	New York	Reported	No record
37007	Anson	North Carolina	Reported	No record
37015	Bertie	North Carolina	Reported	No record
37017	Bladen	North Carolina	Reported	No record
37065	Edgecombe	North Carolina	Reported	No record
37087	Haywood	North Carolina	Reported	No record
37089	Henderson	North Carolina	Reported	No record
37093	Hoke	North Carolina	Reported	No record
37095	Hyde	North Carolina	Reported	No record
37123	Montgomery	North Carolina	Reported	No record
37155	Robeson	North Carolina	Reported	No record
37173	Swain	North Carolina	Reported	No record
37187	Washington	North Carolina	Reported	No record
39011	Auglaize	Ohio	Reported	No record
39015	Brown	Ohio	Reported	No record
39023	Clark	Ohio	Reported	No record
39025	Clermont	Ohio	Reported	No record
39047	Fayette	Ohio	Reported	No record
39063	Hancock	Ohio	Reported	No record
39091	Logan	Ohio	Reported	No record
39117	Morrow	Ohio	Reported	No record
39119	Muskingum	Ohio	Reported	No record
39139	Richland	Ohio	Reported	No record
39151	Stark	Ohio	Reported	No record
39155	Trumbull	Ohio	Reported	No record
40005	Atoka	Oklahoma	Reported	No record
40053	Grant	Oklahoma	Reported	No record
40061	Haskell	Oklahoma	Reported	No record
40079	Le Flore	Oklahoma	Reported	No record
40095	Marshall	Oklahoma	Reported	No record
40121	Pittsburg	Oklahoma	Reported	No record
42075	Lebanon	Pennsylvania	Reported	No record
45001	Abbeville	South Carolina	Reported	No record
45021	Cherokee	South Carolina	Reported	No record
45027	Clarendon	South Carolina	Reported	No record
45039	Fairfield	South Carolina	Reported	No record

FIPS	County	State	Springer et al. 2014 County Status for *A. americanum*	TickSpotters (2014-2019) County Status for *A. americanum*
45049	Hampton	South Carolina	Reported	No record
45053	Jasper	South Carolina	Reported	No record
45077	Pickens	South Carolina	Reported	No record
47017	Carroll	Tennessee	Reported	No record
47021	Cheatham	Tennessee	Reported	No record
47029	Cocke	Tennessee	Reported	No record
47033	Crockett	Tennessee	Reported	No record
47039	Decatur	Tennessee	Reported	No record
47069	Hardeman	Tennessee	Reported	No record
47087	Jackson	Tennessee	Reported	No record
47099	Lawrence	Tennessee	Reported	No record
47135	Perry	Tennessee	Reported	No record
47153	Sequatchie	Tennessee	Reported	No record
47167	Tipton	Tennessee	Reported	No record
47169	Trousdale	Tennessee	Reported	No record
47181	Wayne	Tennessee	Reported	No record
47185	White	Tennessee	Reported	No record
48005	Angelina	Texas	Reported	No record
48007	Aransas	Texas	Reported	No record
48013	Atascosa	Texas	Reported	No record
48015	Austin	Texas	Reported	No record
48017	Bailey	Texas	Reported	No record
48019	Bandera	Texas	Reported	No record
48021	Bastrop	Texas	Reported	No record
48023	Baylor	Texas	Reported	No record
48031	Blanco	Texas	Reported	No record
48035	Bosque	Texas	Reported	No record
48041	Brazos	Texas	Reported	No record
48049	Brown	Texas	Reported	No record
48051	Burleson	Texas	Reported	No record
48055	Caldwell	Texas	Reported	No record
48057	Calhoun	Texas	Reported	No record
48059	Callahan	Texas	Reported	No record
48061	Cameron	Texas	Reported	No record
48067	Cass	Texas	Reported	No record
48087	Collingsworth	Texas	Reported	No record
48089	Colorado	Texas	Reported	No record

FIPS	County	State	Springer et al. 2014 County Status for *A. americanum*	TickSpotters (2014-2019) County Status for *A. americanum*
48091	Comal	Texas	Reported	No record
48111	Dallam	Texas	Reported	No record
48123	De Witt	Texas	Reported	No record
48127	Dimmit	Texas	Reported	No record
48145	Falls	Texas	Reported	No record
48149	Fayette	Texas	Reported	No record
48159	Franklin	Texas	Reported	No record
48161	Freestone	Texas	Reported	No record
48163	Frio	Texas	Reported	No record
48175	Goliad	Texas	Reported	No record
48185	Grimes	Texas	Reported	No record
48205	Hartley	Texas	Reported	No record
48207	Haskell	Texas	Reported	No record
48209	Hays	Texas	Reported	No record
48221	Hood	Texas	Reported	No record
48225	Houston	Texas	Reported	No record
48239	Jackson	Texas	Reported	No record
48241	Jasper	Texas	Reported	No record
48245	Jefferson	Texas	Reported	No record
48247	Jim Hogg	Texas	Reported	No record
48249	Jim Wells	Texas	Reported	No record
48255	Karnes	Texas	Reported	No record
48259	Kendall	Texas	Reported	No record
48261	Kenedy	Texas	Reported	No record
48273	Kleberg	Texas	Reported	No record
48275	Knox	Texas	Reported	No record
48283	La Salle	Texas	Reported	No record
48287	Lee	Texas	Reported	No record
48291	Liberty	Texas	Reported	No record
48293	Limestone	Texas	Reported	No record
48299	Llano	Texas	Reported	No record
48303	Lubbock	Texas	Reported	No record
48307	Mcculloch	Texas	Reported	No record
48311	Mcmullen	Texas	Reported	No record
48313	Madison	Texas	Reported	No record
48321	Matagorda	Texas	Reported	No record
48325	Medina	Texas	Reported	No record

FIPS	County	State	Springer et al. 2014 County Status for *A. americanum*	TickSpotters (2014-2019) County Status for *A. americanum*
48327	Menard	Texas	Reported	No record
48331	Milam	Texas	Reported	No record
48333	Mills	Texas	Reported	No record
48335	Mitchell	Texas	Reported	No record
48351	Newton	Texas	Reported	No record
48353	Nolan	Texas	Reported	No record
48357	Ochiltree	Texas	Reported	No record
48365	Panola	Texas	Reported	No record
48381	Randall	Texas	Reported	No record
48395	Robertson	Texas	Reported	No record
48401	Rusk	Texas	Reported	No record
48405	San Augustine	Texas	Reported	No record
48407	San Jacinto	Texas	Reported	No record
48409	San Patricio	Texas	Reported	No record
48411	San Saba	Texas	Reported	No record
48413	Schleicher	Texas	Reported	No record
48417	Shackelford	Texas	Reported	No record
48419	Shelby	Texas	Reported	No record
48429	Stephens	Texas	Reported	No record
48433	Stonewall	Texas	Reported	No record
48441	Taylor	Texas	Reported	No record
48447	Throckmorton	Texas	Reported	No record
48449	Titus	Texas	Reported	No record
48451	Tom Green	Texas	Reported	No record
48455	Trinity	Texas	Reported	No record
48459	Upshur	Texas	Reported	No record
48469	Victoria	Texas	Reported	No record
48473	Waller	Texas	Reported	No record
48481	Wharton	Texas	Reported	No record
48483	Wheeler	Texas	Reported	No record
48485	Wichita	Texas	Reported	No record
48493	Wilson	Texas	Reported	No record
48505	Zapata	Texas	Reported	No record
48507	Zavala	Texas	Reported	No record
05001	Arkansas	Arkansas	Reported	No record
05003	Ashley	Arkansas	Reported	No record
05011	Bradley	Arkansas	Reported	No record

FIPS	County	State	Springer et al. 2014 County Status for *A. americanum*	TickSpotters (2014-2019) County Status for *A. americanum*
05013	Calhoun	Arkansas	Reported	No record
05017	Chicot	Arkansas	Reported	No record
05019	Clark	Arkansas	Reported	No record
05021	Clay	Arkansas	Reported	No record
05039	Dallas	Arkansas	Reported	No record
05047	Franklin	Arkansas	Reported	No record
05049	Fulton	Arkansas	Reported	No record
05053	Grant	Arkansas	Reported	No record
05057	Hempstead	Arkansas	Reported	No record
05061	Howard	Arkansas	Reported	No record
05065	Izard	Arkansas	Reported	No record
05067	Jackson	Arkansas	Reported	No record
05071	Johnson	Arkansas	Reported	No record
05073	Lafayette	Arkansas	Reported	No record
05079	Lincoln	Arkansas	Reported	No record
05081	Little River	Arkansas	Reported	No record
05083	Logan	Arkansas	Reported	No record
05091	Miller	Arkansas	Reported	No record
05095	Monroe	Arkansas	Reported	No record
05099	Nevada	Arkansas	Reported	No record
51029	Buckingham	Virginia	Reported	No record
05103	Ouachita	Arkansas	Reported	No record
51053	Dinwiddie	Virginia	Reported	No record
05107	Phillips	Arkansas	Reported	No record
51101	King William	Virginia	Reported	No record
51121	Montgomery	Virginia	Reported	No record
51135	Nottoway	Virginia	Reported	No record
51159	Richmond	Virginia	Reported	No record
05117	Prairie	Arkansas	Reported	No record
51181	Surry	Virginia	Reported	No record
05121	Randolph	Arkansas	Reported	No record
05127	Scott	Arkansas	Reported	No record
05139	Union	Arkansas	Reported	No record
05141	Van Buren	Arkansas	Reported	No record
05147	Woodruff	Arkansas	Reported	No record
56021	Laramie	Wyoming	Reported	No record
01009	Blount	Alabama	Reported	Reported

FIPS	County	State	Springer et al. 2014 County Status for *A. americanum*	TickSpotters (2014-2019) County Status for *A. americanum*
01013	Butler	Alabama	Reported	Reported
01029	Cleburne	Alabama	Reported	Reported
01071	Jackson	Alabama	Reported	Reported
01079	Lawrence	Alabama	Reported	Reported
01083	Limestone	Alabama	Reported	Reported
01093	Marion	Alabama	Reported	Reported
01095	Marshall	Alabama	Reported	Reported
01097	Mobile	Alabama	Reported	Reported
01101	Montgomery	Alabama	Reported	Reported
01111	Randolph	Alabama	Reported	Reported
01119	Sumter	Alabama	Reported	Reported
12007	Bradford	Florida	Reported	Reported
12009	Brevard	Florida	Reported	Reported
12023	Columbia	Florida	Reported	Reported
12029	Dixie	Florida	Reported	Reported
12039	Gadsden	Florida	Reported	Reported
12041	Gilchrist	Florida	Reported	Reported
12047	Hamilton	Florida	Reported	Reported
12053	Hernando	Florida	Reported	Reported
12065	Jefferson	Florida	Reported	Reported
12075	Levy	Florida	Reported	Reported
12086	Miami-dade	Florida	Reported	Reported
12099	Palm Beach	Florida	Reported	Reported
12103	Pinellas	Florida	Reported	Reported
12105	Polk	Florida	Reported	Reported
12107	Putnam	Florida	Reported	Reported
12113	Santa Rosa	Florida	Reported	Reported
12115	Sarasota	Florida	Reported	Reported
12119	Sumter	Florida	Reported	Reported
12123	Taylor	Florida	Reported	Reported
12131	Walton	Florida	Reported	Reported
12133	Washington	Florida	Reported	Reported
13013	Barrow	Georgia	Reported	Reported
13031	Bulloch	Georgia	Reported	Reported
13035	Butts	Georgia	Reported	Reported
13057	Cherokee	Georgia	Reported	Reported
13083	Dade	Georgia	Reported	Reported

FIPS	County	State	Springer et al. 2014 County Status for *A. americanum*	TickSpotters (2014-2019) County Status for *A. americanum*
13095	Dougherty	Georgia	Reported	Reported
13129	Gordon	Georgia	Reported	Reported
13145	Harris	Georgia	Reported	Reported
13171	Lamar	Georgia	Reported	Reported
13175	Laurens	Georgia	Reported	Reported
13185	Lowndes	Georgia	Reported	Reported
13189	Mcduffie	Georgia	Reported	Reported
13199	Meriwether	Georgia	Reported	Reported
13219	Oconee	Georgia	Reported	Reported
13223	Paulding	Georgia	Reported	Reported
13225	Peach	Georgia	Reported	Reported
13237	Putnam	Georgia	Reported	Reported
13241	Rabun	Georgia	Reported	Reported
13245	Richmond	Georgia	Reported	Reported
13259	Stewart	Georgia	Reported	Reported
13285	Troup	Georgia	Reported	Reported
13293	Upson	Georgia	Reported	Reported
13295	Walker	Georgia	Reported	Reported
13317	Wilkes	Georgia	Reported	Reported
13319	Wilkinson	Georgia	Reported	Reported
17097	Lake	Illinois	Reported	Reported
17099	La Salle	Illinois	Reported	Reported
17111	Mchenry	Illinois	Reported	Reported
17151	Pope	Illinois	Reported	Reported
17199	Williamson	Illinois	Reported	Reported
18051	Gibson	Indiana	Reported	Reported
18061	Harrison	Indiana	Reported	Reported
18067	Howard	Indiana	Reported	Reported
18093	Lawrence	Indiana	Reported	Reported
18141	St Joseph	Indiana	Reported	Reported
18147	Spencer	Indiana	Reported	Reported
18173	Warrick	Indiana	Reported	Reported
18177	Wayne	Indiana	Reported	Reported
19007	Appanoose	Iowa	Reported	Reported
19061	Dubuque	Iowa	Reported	Reported
19103	Johnson	Iowa	Reported	Reported
19155	Pottawattamie	Iowa	Reported	Reported

FIPS	County	State	Springer et al. 2014 County Status for *A. americanum*	TickSpotters (2014-2019) County Status for *A. americanum*
19181	Warren	Iowa	Reported	Reported
20037	Crawford	Kansas	Reported	Reported
20045	Douglas	Kansas	Reported	Reported
20061	Geary	Kansas	Reported	Reported
20087	Jefferson	Kansas	Reported	Reported
20107	Linn	Kansas	Reported	Reported
20111	Lyon	Kansas	Reported	Reported
20121	Miami	Kansas	Reported	Reported
20169	Saline	Kansas	Reported	Reported
21003	Allen	Kentucky	Reported	Reported
21029	Bullitt	Kentucky	Reported	Reported
21035	Calloway	Kentucky	Reported	Reported
21047	Christian	Kentucky	Reported	Reported
21055	Crittenden	Kentucky	Reported	Reported
21059	Daviess	Kentucky	Reported	Reported
21143	Lyon	Kentucky	Reported	Reported
21163	Meade	Kentucky	Reported	Reported
21177	Muhlenberg	Kentucky	Reported	Reported
21179	Nelson	Kentucky	Reported	Reported
22013	Bienville	Louisiana	Reported	Reported
22015	Bossier	Louisiana	Reported	Reported
22041	Franklin	Louisiana	Reported	Reported
22061	Lincoln	Louisiana	Reported	Reported
23005	Cumberland	Maine	Reported	Reported
23007	Franklin	Maine	Reported	Reported
23009	Hancock	Maine	Reported	Reported
23011	Kennebec	Maine	Reported	Reported
23013	Knox	Maine	Reported	Reported
23019	Penobscot	Maine	Reported	Reported
26025	Calhoun	Michigan	Reported	Reported
26049	Genesee	Michigan	Reported	Reported
26055	Grand Traverse	Michigan	Reported	Reported
26077	Kalamazoo	Michigan	Reported	Reported
26081	Kent	Michigan	Reported	Reported
26087	Lapeer	Michigan	Reported	Reported
26115	Monroe	Michigan	Reported	Reported
26139	Ottawa	Michigan	Reported	Reported

FIPS	County	State	Springer et al. 2014 County Status for *A. americanum*	TickSpotters (2014-2019) County Status for *A. americanum*
26163	Wayne	Michigan	Reported	Reported
28001	Adams	Mississippi	Reported	Reported
28003	Alcorn	Mississippi	Reported	Reported
28021	Claiborne	Mississippi	Reported	Reported
28025	Clay	Mississippi	Reported	Reported
28033	De Soto	Mississippi	Reported	Reported
28043	Grenada	Mississippi	Reported	Reported
28063	Jefferson	Mississippi	Reported	Reported
28071	Lafayette	Mississippi	Reported	Reported
28075	Lauderdale	Mississippi	Reported	Reported
28079	Leake	Mississippi	Reported	Reported
28081	Lee	Mississippi	Reported	Reported
28087	Lowndes	Mississippi	Reported	Reported
28089	Madison	Mississippi	Reported	Reported
28105	Oktibbeha	Mississippi	Reported	Reported
28117	Prentiss	Mississippi	Reported	Reported
28121	Rankin	Mississippi	Reported	Reported
28135	Tallahatchie	Mississippi	Reported	Reported
28137	Tate	Mississippi	Reported	Reported
28149	Warren	Mississippi	Reported	Reported
28157	Wilkinson	Mississippi	Reported	Reported
29017	Bollinger	Missouri	Reported	Reported
29027	Callaway	Missouri	Reported	Reported
29031	Cape Girardeau	Missouri	Reported	Reported
29037	Cass	Missouri	Reported	Reported
29051	Cole	Missouri	Reported	Reported
29055	Crawford	Missouri	Reported	Reported
29083	Henry	Missouri	Reported	Reported
29091	Howell	Missouri	Reported	Reported
29097	Jasper	Missouri	Reported	Reported
29119	Mcdonald	Missouri	Reported	Reported
29121	Macon	Missouri	Reported	Reported
29141	Morgan	Missouri	Reported	Reported
29179	Reynolds	Missouri	Reported	Reported
29186	Ste Genevieve	Missouri	Reported	Reported
29187	St Francois	Missouri	Reported	Reported
29201	Scott	Missouri	Reported	Reported

FIPS	County	State	Springer et al. 2014 County Status for *A. americanum*	TickSpotters (2014-2019) County Status for *A. americanum*
29207	Stoddard	Missouri	Reported	Reported
29209	Stone	Missouri	Reported	Reported
29215	Texas	Missouri	Reported	Reported
29221	Washington	Missouri	Reported	Reported
29223	Wayne	Missouri	Reported	Reported
29225	Webster	Missouri	Reported	Reported
29229	Wright	Missouri	Reported	Reported
29510	St Louis City	Missouri	Reported	Reported
31109	Lancaster	Nebraska	Reported	Reported
31153	Sarpy	Nebraska	Reported	Reported
34011	Cumberland	New Jersey	Reported	Reported
34019	Hunterdon	New Jersey	Reported	Reported
34041	Warren	New Jersey	Reported	Reported
36023	Cortland	New York	Reported	Reported
36027	Dutchess	New York	Reported	Reported
36037	Genesee	New York	Reported	Reported
36039	Greene	New York	Reported	Reported
36051	Livingston	New York	Reported	Reported
36065	Oneida	New York	Reported	Reported
36087	Rockland	New York	Reported	Reported
36091	Saratoga	New York	Reported	Reported
36115	Washington	New York	Reported	Reported
37013	Beaufort	North Carolina	Reported	Reported
37031	Carteret	North Carolina	Reported	Reported
37033	Caswell	North Carolina	Reported	Reported
37039	Cherokee	North Carolina	Reported	Reported
37051	Cumberland	North Carolina	Reported	Reported
37061	Duplin	North Carolina	Reported	Reported
37073	Gates	North Carolina	Reported	Reported
37083	Halifax	North Carolina	Reported	Reported
37097	Iredell	North Carolina	Reported	Reported
37127	Nash	North Carolina	Reported	Reported
37129	New Hanover	North Carolina	Reported	Reported
37141	Pender	North Carolina	Reported	Reported
37143	Perquimans	North Carolina	Reported	Reported
37147	Pitt	North Carolina	Reported	Reported
37179	Union	North Carolina	Reported	Reported

FIPS	County	State	Springer et al. 2014 County Status for *A. americanum*	TickSpotters (2014-2019) County Status for *A. americanum*
37185	Warren	North Carolina	Reported	Reported
39035	Cuyahoga	Ohio	Reported	Reported
39073	Hocking	Ohio	Reported	Reported
39079	Jackson	Ohio	Reported	Reported
39113	Montgomery	Ohio	Reported	Reported
39131	Pike	Ohio	Reported	Reported
39141	Ross	Ohio	Reported	Reported
39145	Scioto	Ohio	Reported	Reported
39163	Vinton	Ohio	Reported	Reported
40001	Adair	Oklahoma	Reported	Reported
40019	Carter	Oklahoma	Reported	Reported
40021	Cherokee	Oklahoma	Reported	Reported
40023	Choctaw	Oklahoma	Reported	Reported
40031	Comanche	Oklahoma	Reported	Reported
40041	Delaware	Oklahoma	Reported	Reported
40047	Garfield	Oklahoma	Reported	Reported
40065	Jackson	Oklahoma	Reported	Reported
40077	Latimer	Oklahoma	Reported	Reported
40081	Lincoln	Oklahoma	Reported	Reported
40097	Mayes	Oklahoma	Reported	Reported
40099	Murray	Oklahoma	Reported	Reported
40101	Muskogee	Oklahoma	Reported	Reported
40113	Osage	Oklahoma	Reported	Reported
40119	Payne	Oklahoma	Reported	Reported
40123	Pontotoc	Oklahoma	Reported	Reported
40125	Pottawatomie	Oklahoma	Reported	Reported
40127	Pushmataha	Oklahoma	Reported	Reported
40135	Sequoyah	Oklahoma	Reported	Reported
42021	Cambria	Pennsylvania	Reported	Reported
42133	York	Pennsylvania	Reported	Reported
44001	Bristol	Rhode Island	Reported	Reported
44009	Washington	Rhode Island	Reported	Reported
45007	Anderson	South Carolina	Reported	Reported
45015	Berkeley	South Carolina	Reported	Reported
45029	Colleton	South Carolina	Reported	Reported
45041	Florence	South Carolina	Reported	Reported
45043	Georgetown	South Carolina	Reported	Reported

FIPS	County	State	Springer et al. 2014 County Status for *A. americanum*	TickSpotters (2014-2019) County Status for *A. americanum*
45047	Greenwood	South Carolina	Reported	Reported
45055	Kershaw	South Carolina	Reported	Reported
45059	Laurens	South Carolina	Reported	Reported
45065	Mccormick	South Carolina	Reported	Reported
45071	Newberry	South Carolina	Reported	Reported
47007	Bledsoe	Tennessee	Reported	Reported
47009	Blount	Tennessee	Reported	Reported
47013	Campbell	Tennessee	Reported	Reported
47049	Fentress	Tennessee	Reported	Reported
47051	Franklin	Tennessee	Reported	Reported
47055	Giles	Tennessee	Reported	Reported
47071	Hardin	Tennessee	Reported	Reported
47081	Hickman	Tennessee	Reported	Reported
47107	Mcminn	Tennessee	Reported	Reported
47109	Mcnairy	Tennessee	Reported	Reported
47113	Madison	Tennessee	Reported	Reported
47115	Marion	Tennessee	Reported	Reported
47117	Marshall	Tennessee	Reported	Reported
47121	Meigs	Tennessee	Reported	Reported
47123	Monroe	Tennessee	Reported	Reported
47129	Morgan	Tennessee	Reported	Reported
47139	Polk	Tennessee	Reported	Reported
47141	Putnam	Tennessee	Reported	Reported
47143	Rhea	Tennessee	Reported	Reported
47147	Robertson	Tennessee	Reported	Reported
47155	Sevier	Tennessee	Reported	Reported
47163	Sullivan	Tennessee	Reported	Reported
47175	Van Buren	Tennessee	Reported	Reported
47177	Warren	Tennessee	Reported	Reported
47183	Weakley	Tennessee	Reported	Reported
48037	Bowie	Texas	Reported	Reported
48047	Brooks	Texas	Reported	Reported
48063	Camp	Texas	Reported	Reported
48085	Collin	Texas	Reported	Reported
48099	Coryell	Texas	Reported	Reported
48105	Crockett	Texas	Reported	Reported
48119	Delta	Texas	Reported	Reported

FIPS	County	State	Springer et al. 2014 County Status for *A. americanum*	TickSpotters (2014-2019) County Status for *A. americanum*
48131	Duval	Texas	Reported	Reported
48137	Edwards	Texas	Reported	Reported
48157	Fort Bend	Texas	Reported	Reported
48167	Galveston:main	Texas	Reported	Reported
48167	Galveston:main	Texas	Reported	Reported
48167	Galveston:spit	Texas	Reported	Reported
48167	Galveston:spit	Texas	Reported	Reported
48181	Grayson	Texas	Reported	Reported
48183	Gregg	Texas	Reported	Reported
48203	Harrison	Texas	Reported	Reported
48231	Hunt	Texas	Reported	Reported
48257	Kaufman	Texas	Reported	Reported
48309	Mclennan	Texas	Reported	Reported
48329	Midland	Texas	Reported	Reported
48339	Montgomery	Texas	Reported	Reported
48349	Navarro	Texas	Reported	Reported
48373	Polk	Texas	Reported	Reported
48385	Real	Texas	Reported	Reported
48397	Rockwall	Texas	Reported	Reported
48423	Smith	Texas	Reported	Reported
48427	Starr	Texas	Reported	Reported
48435	Sutton	Texas	Reported	Reported
48463	Uvalde	Texas	Reported	Reported
48467	Van Zandt	Texas	Reported	Reported
48471	Walker	Texas	Reported	Reported
48491	Williamson	Texas	Reported	Reported
05005	Baxter	Arkansas	Reported	Reported
05015	Carroll	Arkansas	Reported	Reported
05027	Columbia	Arkansas	Reported	Reported
05029	Conway	Arkansas	Reported	Reported
05033	Crawford	Arkansas	Reported	Reported
05045	Faulkner	Arkansas	Reported	Reported
05059	Hot Spring	Arkansas	Reported	Reported
05063	Independence	Arkansas	Reported	Reported
05069	Jefferson	Arkansas	Reported	Reported
05075	Lawrence	Arkansas	Reported	Reported
05087	Madison	Arkansas	Reported	Reported

FIPS	County	State	Springer et al. 2014 County Status for *A. americanum*	TickSpotters (2014-2019) County Status for *A. americanum*
05097	Montgomery	Arkansas	Reported	Reported
51001	Accomack:chincoteague	Virginia	Reported	Reported
51001	Accomack:chincoteague	Virginia	Reported	Reported
51001	Accomack:main	Virginia	Reported	Reported
51001	Accomack:main	Virginia	Reported	Reported
51011	Appomattox	Virginia	Reported	Reported
51015	Augusta	Virginia	Reported	Reported
51023	Botetourt	Virginia	Reported	Reported
51025	Brunswick	Virginia	Reported	Reported
51036	Charles City	Virginia	Reported	Reported
51049	Cumberland	Virginia	Reported	Reported
05109	Pike	Arkansas	Reported	Reported
51097	King And Queen	Virginia	Reported	Reported
51111	Lunenburg	Virginia	Reported	Reported
51127	New Kent	Virginia	Reported	Reported
05113	Polk	Arkansas	Reported	Reported
51141	Patrick	Virginia	Reported	Reported
51145	Powhatan	Virginia	Reported	Reported
51149	Prince George	Virginia	Reported	Reported
51155	Pulaski	Virginia	Reported	Reported
51175	Southampton	Virginia	Reported	Reported
51193	Westmoreland	Virginia	Reported	Reported
05129	Searcy	Arkansas	Reported	Reported
05131	Sebastian	Arkansas	Reported	Reported
05133	Sevier	Arkansas	Reported	Reported
05135	Sharp	Arkansas	Reported	Reported
05145	White	Arkansas	Reported	Reported
05149	Yell	Arkansas	Reported	Reported
51710	Norfolk	Virginia	Reported	Reported
55035	Eau Claire	Wisconsin	Reported	Reported

Appendix 7. Tick-borne Disease Exposure and Prevention Behavior Survey

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Start of Block: Consent Information

Q35 **THE OPPORTUNITY TO PARTICIPATE IN THIS SURVEY WILL END ON JANUARY 31st, 2020 at 11:59pm EST.** This is an invitation to participate in a survey about your experience with ticks and tick-borne disease. The purpose of the study is to understand how exposure to tick habitat is related to choice in prevention behaviors and methods, as well as attitudes towards these methods. Please **read the following** before agreeing to be in the study. By clicking "I CONSENT" below , you indicate that you have read and understood the information contained in the link and volunteer to participate in this study. ~~~~~~ It will take you no more than 15-20 minutes to complete this survey. There are no known risks to participating in this survey, nor compensation beyond being entered into a random drawing to win a Visa gift card (either $50 or $20 amount), or a pair of TickEase tweezers. Benefits of participating in our study, however, may include learning about tick ecology, biology, and tick bite prevention strategies. Your personal information will be strictly confidential, and responses de-identified from your email. The responses may be used in research papers and in graphs that may be displayed to the public at academic conferences. The decision to participate in this study is entirely voluntary. You may refuse to take part in the study at any time without affecting your relationship with the investigators of this study or the University of Rhode Island (URI). Your decision will not result in any loss of benefits to which you are otherwise entitled. You have the right not to answer any single question, as well as to withdraw completely from the survey at any point during the process; additionally, you have the right to request that the researchers not use any of your responses. You have the right to ask questions about this research study and to have those questions answered by me before, during or after the research. For questions about the study contact **Dr. Thomas Mather** from the Plant Sciences and Entomology Department/College of Environment and Life Sciences, at **401-874-2928** or **tmather@uri.edu**. Additionally, you may contact the URI Institutional Review Board (IRB) if you have questions regarding your rights as a research participant. Also contact the IRB if you have questions, complaints or concerns which you do not feel you can discuss with the investigator. The University of Rhode Island IRB may be reached by phone at (401) 874-4328 or by e-mail at researchintegrity@etal.uri.edu. You may also contact the URI Vice President for Research and Economic Development by phone at (401) 874-4576. If you would like to keep a copy of this document for your records, please print or save this page now. You may also contact the researcher to request a copy. Sincerely, Dr. Thomas Mather, Primary Investigator University of Rhode Island TickEncounter Resource Center URI Center for Vector-borne Disease tmather@uri.edu Heather Kopsco Ph.D. candidate, Co-investigator University of Rhode Island TickEncounter Resource Center URI Center for Vector-borne Disease hkopsco@uri.edu **NOTE WHEN COMPLETING THE SURVEY**: SCROLL ALL THE WAY TO THE RIGHT TO VIEW THE "CONTINUE TO THE NEXT PAGE" BUTTON.

THE UNIVERSITY OF RHODE ISLAND

Q36 Do you consent to participate in this research study?

- ○ I consent. (1)
- ○ I do not consent. (2)

End of Block: Consent Information

Start of Block: Test and Control Group Validation

A1 Have you ever submitted a photo to the TickSpotters program?

- ○ Yes (1)
- ○ No (2)

Display This Question:

If Have you ever submitted a photo to the TickSpotters program? = No

Q41 Are you a certified Master Gardener?

- ○ Yes (1)
- ○ No (2)

Display This Question:

If Are you a certified Master Gardener? = Yes

Q43 For how long have you been a Master Gardener?

- ○ Less than a year (1)
- ○ 1-2 years (2)
- ○ 3-5 years (3)
- ○ 6-10 years (4)
- ○ More than 10 years (5)

End of Block: Test and Control Group Validation

Start of Block: All Respondents

A2 Where do you get information on tick-bite prevention? (Select all that apply.)

- [ ] Centers for Disease Control and Prevention (1)
- [ ] TickEncounter Resource Center (2)
- [ ] LymeDisease.org or other Lyme disease-focused organization (3)
- [ ] WebMD or other mainstream medical website (4)
- [ ] Primary care physician (5)
- [ ] Social media sites (e.g. Facebook, Twitter, Instagram) (6)
- [ ] Friends and family (7)
- [ ] Lyme-literate medical doctor (8)
- [ ] Other University or academic-based resource (10)
- [ ] Other (9) _____

A3 How often do you:

	Never (1)	Sometimes (2)	About half the time (3)	Most of the time (4)	Always (5)
Use a tick repellent with DEET on exposed skin before working or playing in tick habitat? (1)	○	○	○	○	○
Wear long pants when entering a tick-infested area? (2)	○	○	○	○	○
Tuck your pants into socks to keep ticks on the outside of clothes? (3)	○	○	○	○	○
Use a tick repellent that contains permethrin on your clothing? (4)	○	○	○	○	○
Check yourself for ticks after being outdoors? (5)	○	○	○	○	○
Avoid areas that may have ticks (trail edges, etc)? (6)	○	○	○	○	○
Check children/pets for ticks after outdoor activity? (7)	○	○	○	○	○

A4 When you find a tick that is attached to you/family member/pet, how often do you:

	Never (1)	Sometimes (2)	About half the time (3)	Most of the time (4)	Always (5)
Remove the tick immediately? (1)	○	○	○	○	○
Use your fingers to remove the tick? (2)	○	○	○	○	○
Apply oils or other substances to get the tick to "back out?" (3)	○	○	○	○	○
Use pointy tweezers to remove the tick? (4)	○	○	○	○	○
Save the tick for later identification or testing? (5)	○	○	○	○	○
Immediately contact a physician? (6)	○	○	○	○	○
Record the date it was found and watch for symptoms? (7)	○	○	○	○	○
Experience anxiety about potential tick-borne illnesses? (8)	○	○	○	○	○

C1 What tick bite prevention methods do you currently use? (Select that all apply.)

- [ ] Daily tick checks (1)
- [ ] At-home treatment of clothing with permethrin spray (2)
- [ ] Purchasing and wearing pre-treated permethrin clothing (3)
- [ ] Treating yards with synthetic pesticides (e.g. bifenthrin) (4)
- [ ] Treating yards with natural/organic pesticides (e.g. cedar oil) (5)
- [ ] Tucking pants into socks when in tick habitat (6)
- [ ] Wearing light-colored clothing when in tick habitat (7)
- [ ] Chewable pet preventative (e.g. Bravecto, NexGard, Simparica) (8)
- [ ] Topical pet preventative (e.g. Frontline, K9 Advantix) (15)
- [ ] Collar pet preventative (e.g. Seresto, Preventic) (9)
- [ ] Natural pet preventatives (e.g. Sentry, essential oils) (10)
- [ ] Bug spray containing EPA-approved repellent (e.g. DEET, picaridin) (11)
- [ ] Natural/organic bug spray repellent (12)
- [ ] Saving a tick to be identified or tested later (13)
- [ ] None (16)
- [ ] Other (14) _____

A5 What treatments do you use to prevent ticks in your yard? (Select all that apply.)

- ☐ Natural pesticide sprayed/spread by a licensed applicator. (1)
- ☐ Synthetic pesticide sprayed/spread by a licensed applicator. (2)
- ☐ I spray/spread natural pesticide myself. (3)
- ☐ I spray/spread synthetic pesticide myself. (4)
- ☐ Deer fencing (5)
- ☐ Wood chip barriers (6)
- ☐ Rodent-targeted devices (e.g. tick tubes, bait boxes) (7)
- ☐ None (9)
- ☐ Other (8) _____

A6 In the last year, did anyone in your household find a tick (Select all that apply.):

- ☐ on a person? (1)
- ☐ on a pet? (2)
- ☐ loose and wandering in the home? (3)
- ☐ No ticks were found in the past year. (4)

A7 If a tick was found in the past year, was a health care provider (physician/veterinarian) consulted?

- ○ Yes (1)
- ○ No (2)
- ○ No ticks were found in the past year. (3)

A8 Have you or anyone in your household ever been diagnosed with any of the following tick-borne illnesses? (Select all that apply.)

- ☐ Lyme disease (1)
- ☐ Babesiosis (2)
- ☐ Anaplasmosis (3)
- ☐ Ehrlichiosis (4)
- ☐ Southern tick-associated rash illness (5)
- ☐ Tularemia (6)
- ☐ Tick-borne relapsing fever (e.g. Borrelia miyamotoi infection) (8)
- ☐ Rocky Mountain Spotted fever or other rickettsial illness (9)
- ☐ Alpha-gal (read meat) allergy (10)
- ☐ Powassan virus (11)
- ☐ None (13)
- ☐ Other (12) _____

A9 Do you or someone you know suffer from chronic symptoms of Lyme disease?

- ○ Yes (1)
- ○ No (2)

A10 Which of the following ticks occur in the area where you live? (Select all that apply.)

- ☐ Blacklegged (deer) tick (Ixodes scapularis) (1)
- ☐ American dog tick (Dermacentor variabilis) (2)
- ☐ Lone star tick (Amblyomma americanum) (3)
- ☐ Brown dog tick (Rhipicephalus sanguineus) (4)
- ☐ Pacific coast tick (Dermacentor occidentalis) (5)
- ☐ Gulf coast tick (Amblyomma maculatum) (6)
- ☐ Western blacklegged tick (Ixodes pacificus) (7)
- ☐ Moose (Winter) tick (Dermacentor albipictus) (8)
- ☐ Cayenne tick (Amblyomma cajennese) (9)
- ☐ Rocky Mountain Wood tick (Dermacentor andersoni) (10)
- ☐ I don't know which ticks occur in my area. (11)

A11 Which of the following diseases are spread by ticks that occur in the area where you live? (Select all that apply.)

- ☐ Lyme disease (1)
- ☐ Babesiosis (2)
- ☐ Anaplasmosis (3)
- ☐ Ehrlichiosis (4)
- ☐ Southern tick-associated rash illness (5)
- ☐ Tularemia (6)
- ☐ Tick-borne relapsing fever (e.g. Borrelia miyamotoi infection) (8)
- ☐ Rocky Mountain Spotted fever or other rickettsial illness (9)
- ☐ Alpha-gal (red meat) allergy (10)
- ☐ Powassan virus (11)
- ☐ Other (12) _____
- ☐ I don't know which diseases are spread by ticks in my area. (13)

A12 Would you apply synthetic pesticides one or two times per year if they would reduce the number of ticks in your yard/on your property by at least 50%?

- ○ I already apply pesticides to my yard/property one-two times per year. (1)
- ○ Yes, I would consider applying pesticides to my yard/property. (2)
- ○ Maybe I would apply pesticides to my yard/property. (3)
- ○ No, I would not apply pesticides to my yard/property. (4)
- ○ I'm not sure. (5)
- ○ I don't have a yard/property to treat. (6)

A13 For the following statements, please answer according to the following scale:

	Disagree (1)	Somewhat disagree (2)	Neither agree nor disagree (3)	Somewhat agree (4)	Agree (5)
I am afraid of contracting a tickborne disease. (1)	○	○	○	○	○
Most tick-borne diseases are easily cured with antibiotics. (2)	○	○	○	○	○
Tick-borne diseases can be dangerous if left untreated for a long period of time. (3)	○	○	○	○	○
I feel confident in my ability to protect myself and my family from tick bites. (4)	○	○	○	○	○
Regular tick checks will help protect me from contracting a tick-borne disease. (5)	○	○	○	○	○
I would like to use a yard spray to prevent ticks in my backyard but they are too expensive. (6)	○	○	○	○	○
I opt for "all-natural" repellent sprays because I am uncomfortable with chemicals like permethrin or picaridin. (7)	○	○	○	○	○
I am concerned about the effect that spraying pesticides in my yard will have on pollinator and non-target insects. (9)	○	○	○	○	○
Permethrin is a highly effective tick repellent. (8)	○	○	○	○	○

A14 Which of these ticks transmits the Lyme disease bacteria to humans and pets? (Select all that apply.)

- [ ] Image:Adt (1)
- [ ] Image:Blt (2)
- [ ] Image:Bdt (3)
- [ ] Image:Lst (4)
- [ ] I don't know. (5)

A15 Which of these ticks is called the American dog tick or “wood tick?” (Select only one.)

- ○ Image:Bdt (1)
- ○ Image:Lst (2)
- ○ Image:Adt (3)
- ○ Image:Blt (4)
- ○ I don't know. (5)

A16 During which season are you most likely to encounter a **NYMPH** stage blacklegged (deer) tick (*Ixodes scapularis*) in the northeastern U.S. or upper midwest? (Select all that apply.)

- ☐ Spring (April - June) (1)
- ☐ Summer (June - August) (2)
- ☐ Fall (September - November) (3)
- ☐ Winter (December - March) (4)
- ☐ I don't know. (5)

A17 During which season are you most likely to encounter an adult FEMALE stage blacklegged (deer) tick (Ixodes scapularis) in the northeastern U.S. or upper midwest? (Select all that apply.)

- ☐ Spring (April-June) (1)
- ☐ Summer (June-August) (2)
- ☐ Fall (September-November) (3)
- ☐ Winter (December - March) (4)
- ☐ I don't know. (5)

Q33 During which season are you most likely to encounter a NYMPH stage western-blacklegged (deer) tick (Ixodes pacificus) in the western U.S.? (Select all that apply.)

- [ ] Spring (April-June) (1)
- [ ] Summer (June-August) (2)
- [ ] Fall (September-November) (3)
- [ ] Winter (December - March) (4)
- [ ] I don't know. (5)

Q34 During which season are you most likely to encounter an adult FEMALE stage western-blacklegged (deer) tick (Ixodes pacificus) in the western U.S.? (Select all that apply.)

- [ ] Spring (April-June) (1)
- [ ] Summer (June-August) (2)
- [ ] Fall (September-November) (3)
- [ ] Winter (December - March) (4)
- [ ] I don't know. (5)

End of Block: All Respondents

Start of Block: TickSpotters Users

Display This Question:

If Have you ever submitted a photo to the TickSpotters program? = Yes

T1 In total, how many reports have you submitted to TickSpotters?

▼ 1 (1) ... More than 5 submissions (4)

Display This Question:

If Have you ever submitted a photo to the TickSpotters program? = Yes

T2 What tick bite prevention methods did you use **BEFORE** receiving an e-mail with best next actions from the TickSpotters program? (Select that all apply)

- ☐ Daily tick checks (1)
- ☐ At-home treatment of clothing with permethrin spray (2)
- ☐ Purchasing and wearing pre-treated permethrin clothing (3)
- ☐ Treating yards with synthetic pesticides (e.g. bifenthrin) (4)
- ☐ Treating yards with natural/organic pesticides (e.g. cedar oil) (5)
- ☐ Tucking pants into socks when in tick habitat (6)
- ☐ Chewable pet preventative (e.g. Bravecto, NexGard, Simparica) (7)
- ☐ Topical pet preventative (e.g. Frontline, K9 Advantix) (14)
- ☐ Collar pet preventative (e.g. Seresto, Preventic) (8)
- ☐ Natural pet preventatives (e.g. Sentry, essential oils) (9)
- ☐ Bug spray containing EPA-approved repellent (e.g. DEET, picaridin) (10)
- ☐ Natural bug spray repellent (11)
- ☐ Saving a tick to be identified or tested later (12)
- ☐ None (15)
- ☐ Other (13) _____

Display This Question:

If Have you ever submitted a photo to the TickSpotters program? = Yes

T3 Of the following, what tick bite prevention methods did you use AFTER receiving an e-mail with prevention ideas from the TickSpotters program? (Select that all apply.)

- ☐ Daily tick checks (1)
- ☐ At-home treatment of clothing with permethrin spray (2)
- ☐ Purchasing and wearing pre-treated permethrin clothing (3)
- ☐ Treating yards with synthetic pesticides (e.g. bifenthrin) (4)
- ☐ Treating yards with natural/organic pesticides (e.g. cedar oil) (5)
- ☐ Tucking pants into socks when in tick habitat (6)
- ☐ Chewable pet preventative (e.g. Bravecto, NexGard, Simparica) (7)
- ☐ Topical pet preventative (e.g. Frontline, K9 Advantix) (14)
- ☐ Collar pet preventative (e.g. Seresto, Preventic) (8)
- ☐ Natural pet preventatives (e.g. Sentry, essential oils) (9)
- ☐ Bug spray containing EPA-approved repellent (e.g. DEET, picaridin) (10)
- ☐ Natural bug spray repellent (11)
- ☐ Saving a tick to be identified or tested later (12)
- ☐ None (16)
- ☐ Other (13) _____

Display This Question:

If Have you ever submitted a photo to the TickSpotters program? = Yes

T4 For the statements below, please answer according to the following scale:

	Agree (1)	Somewhat agree (2)	Neither agree nor disagree (3)	Somewhat disagree (4)	Disagree (5)
I found the TickSpotters submission process easy to complete. (1)	○	○	○	○	○
I received a response within the estimated time window. (2)	○	○	○	○	○
I found the tick biology and disease information helpful. (3)	○	○	○	○	○
I found the prevention suggestions useful. (4)	○	○	○	○	○
The TickSpotters response email put me at ease. (5)	○	○	○	○	○
I feel empowered to protect myself and my family with the information I learned from TickSpotters (6)	○	○	○	○	○
I have adopted/plan to adopt new prevention behaviors as a result of what I learned from TickSpotters. (7)	○	○	○	○	○
I will continue to use the TickSpotters system for tick identification and risk assessment. (8)	○	○	○	○	○

Display This Question:

If Have you ever submitted a photo to the TickSpotters program? = Yes

T5 Are there any suggestions you have regarding the TickSpotters program?

_____

_____

_____

_____

_____

End of Block: TickSpotters Users

Start of Block: Demographics

A18 To what gender do you most closely identify?

▼ Male (1) ... Prefer not to answer (7)

A19 How many children (age 17 and younger) live with you?

▼ 0 (1) ... More than 4 (6)

A20 What is your current employment status?

▼ Working full-time (35 or more hours/week) (1) ... I prefer not to answer. (7)

A21 What is the highest level of school you have completed or the highest degree you have received?

▼ Less than high school degree (1) ... I prefer not to answer (9)

A22 In which state do you currently reside?

▼ Alabama (1) ... I do not reside in the United States (53)

A23 How would you describe the area in which you live?

▼ City (1) ... Rural (4)

A24 Are you Spanish, Hispanic, or Latino?

- ○ Yes (1)
- ○ No (2)
- ○ Prefer not to answer (3)

A25 Choose one or more races that you consider yourself to be:

- ☐ White (1)
- ☐ Black or African American (2)
- ☐ American Indian or Alaska Native (3)
- ☐ Asian (4)
- ☐ Native Hawaiian or Pacific Islander (5)
- ☐ I prefer not to answer. (7)
- ☐ Other (6) _____

A26 What is your annual income?

▼ Less than $50,000 (1) ... I prefer not to answer. (8)

Q37 Please enter your email for a chance to be entered into a drawing to win either $50 or $20 Visa gift card or a pair of TickEase tweezers.

_____

Q38 Please verify your email by reentering it.